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SIXTH ANNUAL REPORT
of the
U. S. Regional Pasture Research Laboratory
State College, Pa.
1942

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1942

Sixth Annual Report

U. S. Regional Pasture Research Laboratory

State College, Pennsylvania

Division of Forage Crops and Diseases

Bureau of Plant Industry

and

The Agricultural Experiment Stations

of the

Northeastern States

Cooperating

Forty copies of this Report were made and distributed as follows:

Three copies to the Division of Forage Crops and Diseases; one copy to each of the twelve Directors of the cooperating State Agricultural Experiment Stations in the Northeastern United States; one copy to the President of the Pennsylvania State College; one copy to the Conservator of the Northeastern Region of the Soil Conservation Service, Upper Darby, Pa.; one copy to the Director of each of the following State Agricultural Experiment Stations - Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Tennessee, Virginia, and Wisconsin; one copy to the Dominion Agrostologist, Ottawa, Canada; one copy to the Dean of Agriculture, Saskatoon, Saskatchewan, Canada; one copy to the Director of the Welsh Plant Breeding Station, Aberystwyth, Wales; one copy to the Director of the Swedish Seed Growers Association, Svalof, Sweden; one copy to the Director of the Faite Agricultural Research Institute, Adelaide, Australia; and the remaining four copies to the U. S. Regional Pasture Research Laboratory.

B.

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* This annual report of activity at the Pasture *
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* stations with which the Laboratory cooperates, *
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REPORT
of the
UNITED STATES REGIONAL PASTURE RESEARCH LABORATORY

For the Calendar Year 1942

INTRODUCTION

A year ago we, at the Pasture Laboratory along with many other agricultural research workers, were somewhat uncertain as to what steps should be taken in modifying our research program to help meet more effectively the agricultural demands of a nation at war. Most of the research carried on at the Laboratory was projected on a long time basis and with the needs of the Northeastern Region as a whole in mind. These considerations made drastic changes seem unwise. However, it was possible to shift somewhat the relative emphasis in the then current researches and to initiate some new work. Steps have been taken to speed up the breeding of improved strains of pasture grasses and legumes and greater emphasis has been given to the studies of seed treatment to control damping off. Effective seed treatments would make possible lowered rates of seeding and under some conditions facilitate obtaining a good stand of seedlings. The new work is concerned with pasture renovation. There are many acres of pastures in the Northeastern Region that could be made more productive throughout the grazing season by the adoption of proper renovation practices. The new experiments are designed to give results of direct practical importance in several places in the Region. These changes and additions have been made without unduly sacrificing any important part of the research program as previously outlined.

The present report is patterned after the ones prepared in recent years. Progress on cooperative projects between state stations and the Laboratory is reported in a separate section. This is followed by a discussion of activity at the Laboratory and a list of papers published or in the process of publication. The state reports together with their subject matter index and references to publications occur in the appendix.

CHANGES IN PERSONNEL

Miss Martha Jayne, technical assistant in Plant Physiology and Chemistry, resigned to accept a position elsewhere. Miss Marjorie R. Chambers has been appointed, effective January 4, 1943, to fill the vacancy.

Miss Marion D. Fisher was appointed secretary to succeed Miss Tracy J. Trachsel.

ACTIVITIES RELATING TO COORDINATION OF RESEARCH

In accordance with suggestions made by the Directors of the State Agricultural Experiment Stations in the Region, the usual annual meeting of collaborators was not held in 1942. It will be recalled that at the last annual meeting the discussion hinged around the general topic, "Effect of Environmental Factors upon Growth and Development of Pasture Plants". At this meeting the appointment of a special committee was proposed to consider pasture-weather relations. The committee's suggestions were distributed to the collaborators and during the present year some progress was made along the lines indicated by the committee but conditions created by the war have seriously hampered the development of this project.

During the calendar year of 1942 three additional memoranda of understanding were drawn up as a basis for proposed cooperative projects between state stations and the Laboratory. The Laboratory now has or is in the process of establishing formal cooperative projects with ten of the twelve state experiment stations in the Region. In the next section progress on these cooperative projects is reported.

COOPERATIVE RESEARCH BETWEEN STATE STATIONS AND THE LABORATORY

PASTURE RENOVATION EXPERIMENTS

With the urgent need for increased forage production in the Northeastern Region it seemed advisable to investigate in some detail the possibilities of obtaining higher and more uniformly distributed yields on pasture areas by a system of liming and mineral fertilization plus the use of some of the larger grasses and legumes either grown singly or in mixtures. The types of pasture to which this system may be adapted includes those areas which are potentially productive but at present are low yielding due to low fertility, to mismanagement, or to other conditions which may have reduced the productivity of the sward.

Cooperative trials have been initiated to determine the total yield, the distribution of this yield throughout the season and the persistence of several adapted grasses and legumes including orchard grass, brome grass, timothy, Kentucky bluegrass, Reed canary grass, perennial ryegrass, tall fescue, alfalfa, sweet clover, red clover, alsike clover, Ladino clover and Birdsfoot trefoil. In addition to species trials, methods of seed bed preparation on plowable and non-plowable pastures and fertilizer placement studies are being conducted. Several of the experimental areas were worked and fertilized in the fall of 1942, but seedings will not be made before the early spring of 1943.

The agencies cooperating on these studies include: Connecticut (Storrs) Agricultural Experiment Station, Maine Agricultural Experiment Station, Massachusetts Agricultural Experiment Station, Pennsylvania Agricultural Experiment Station, Rhode Island Agricultural Experiment Station, Vermont Agricultural Experiment Station, Division of Forage Crops and Diseases, U. S. Department of Agriculture, and the Pasture Laboratory.

AGROSTIS TENUIS BREEDING (WITH RHODE ISLAND)

Title: Breeding Rhode Island Colonial Bent Grass for Pasture Types.

Leaders: For the Rhode Island Agricultural Experiment Station - J. A. DeFrance, J. F. Stephenson and R. E. Larson.

For the Pasture Research Laboratory - V. H. Myers.

The field nursery of approximately 5,000 spaced plants (1941 Annual Report, Page 6) was continued and further notes were taken until late fall when a considerable number of inferior plants were discarded. Seven more promising selections were made and will be planted in clonal plots along with the 207 selections previously made (1941 Annual Report).

Records of the clonal plots were taken in 1942 on vigor, leaf type, foliage density, growth habit, date of heading, height at maturity, seed production, lodging, rapidity of recovery from cutting, density of plant and disease resistance to help in the determination of further selections for breeding experiments. It was noted that vigor and all characters varied considerably among the different plants; seed heads emerged within a twelve day interval; the amount of seed heads produced ranged from practically none to a dense mass; some heavy seed producers did not lodge; and a few were relatively free of disease, such as rust and leaf spot. The ability of the plants to make a quick recovery from cutting also varied widely. These notes and observations indicate that there is apparently a wide range of genetic material of which valuable use can be made for further combinations. The most promising strains of the clonal plots were selfed in 1942.

An attempt was made to classify the plants in the various clonal plots into characteristic plant types. Clones of 32 plants representing eight plant types were chosen for the purpose of intercrossing within types and will be sent to the Regional Pasture Laboratory for planting in isolated plots.

Plantings made in the nursery in the spring of 1942 from selections made in 1941 and grown in the greenhouse are as follows:

1. 671 plants representing 70 progenies from cross-pollinated material.
2. 280 plants representing 25 progenies from selfed seed.
3. 33 plants representing 9 progenies from previously selfed material.
4. 2,671 plants representing 74 progenies from cross-pollinated seed of variable material.

Based on observations during the 1942 season, 15 selections were made of the open-pollinated plants, four from the selfed plants and 22 from the variable material for the purpose of planting in the clonal plots in the spring of 1943. In addition, seed heads were collected from self- and open-pollinated plants and seed will be planted in the greenhouse early in 1943 and later plants will be transferred to the field for further observation.

An accompanying study shows that the taxonomy of Agrostis tenuis, A. alba, A. stolonifera, and A. palustris is apparently quite confused. There appears to be considerable variation between species grading one into the other. A cytological investigation has been started in an attempt to end the confusion as well as to yield valuable data which will aid in securing true breeding stock. Counts of the chromosomes of three open-pollinated progenies showed ranges from 33 to 42 in one, 31 to 35 in another and 28 to 39 in the third. The chromosome numbers of a strain of New Zealand bent and of two inbred strains of Colonial bent were 42, 35 and 28; of two inbred strains of redtop, 40 and 34. These counts do not agree with those reported in the literature.

ANATOMY OF GRASS SEEDLINGS (WITH RHODE ISLAND)

Title: The anatomy of grass seedlings as influenced by environmental factors under controlled conditions.

Leaders: For the Rhode Island Agricultural Experiment Station -
Irene H. Stuckey.

For the Pasture Research Laboratory - V. G. Sprague.

To investigate further the effect of photoperiod on cell size of grass leaves which was begun at the Rhode Island Station earlier (1940 Annual Report, Page 99) and to determine whether the size of such cells was related to temperature or an interaction of temperature and photoperiod, leaves from several species of

plants grown at two day lengths and four temperatures (Page 43) were used. Measurements of the lengths of cells from these species, while not yet complete, exhibited several trends: The response of the grass is specific; in some species the cells were longer with a 16-hour photoperiod, in others they were longer from plants grown at a certain temperature; and the vessel elements, fibers and epidermal cells responded in the same direction.

CHEMICAL COMPOSITION OF PASTURE GRASSES (WITH NEW HAMPSHIRE)

Title: The Chemical Composition of Pasture Grasses.

Leaders: For the New Hampshire Agricultural Experiment
Station - T. G. Phillips and T. O. Smith.
For the Pasture Research Laboratory - J. T.
Sullivan.

Analyses of timothy plants described previously (1940 Annual Report, Page 12) have been completed. These samples include the heads, leaves, upper stalks, and lower stalks at the pre-bloom and early bloom stages during one season. Again, two cuttings of the tops and the corms in one year and three cuttings of the tops in another year have been analyzed.

Extensive analyses have been made with special consideration of the carbohydrate fractions. The alcohol soluble portions have been analyzed for solids, nitrogen, glucose, fructose, and sucrose; the insoluble portions for solids, nitrogen, lignin, cellulose, and hydrolyzable carbohydrates. The hydrolyzable carbohydrates were determined by subjecting separate samples to the following treatments: (1) Hydrolysis by 0.2N H_2SO_4 in the boiling water bath for 20 minutes, (2) hydrolysis by takadiastase for 40 hours at 38° C., and (3) hydrolysis with 1.0N H_2SO_4 for 2.5 hours in the boiling water bath. In the filtrate from each of these treatments determinations were made of direct reducing power, reducing power after oxidation with iodine and reducing power after fermentation with bakers' yeast. The results are being prepared for publication.

Six miscellaneous samples of bluegrass and ryegrass have been successively extracted with water at 40° for 16 hours until no more carbohydrates were dissolved, then similarly with takadiastase for 48 hours at 40°, then with 0.2N H_2SO_4 for one hour at 80°. The water extracts were subjected to takadiastase hydrolysis and to hydrolysis with 2.0N H_2SO_4 for one hour at 80°. The takadiastase and 0.2N acid extracts were further

hydrolyzed with the stronger acid. On each of the extracts and hydrolyzates obtained determinations were made of direct reducing power, reducing power after oxidation with iodine and reducing power after fermentation with bakers' yeast.

Considerable amounts of carbohydrate material were dissolved by the water and takadiastase treatments but had relatively small reducing power until after further hydrolysis with strong acid. Likewise much carbohydrate material was dissolved but not completely hydrolyzed by 0.2N acid and was further hydrolyzed with stronger acid. Extraction with water at 40° did not remove all fructosan in each sample. Successive extractions with takadiastase removed it but did not hydrolyze it. A single treatment with dilute acid was sufficient to extract and hydrolyze it.

DACTYLIS GLOMERATA, LOLIUM PERENNE, AND FESTUCA SPP.

BREEDING

(WITH MARYLAND

AND

DIVISION OF FORAGE CROPS AND DISEASES)

Title: Selection, Inbreeding, and Crossing to Obtain Orchard Grass (Dactylis glomerata), Ryegrass (Lolium perenne, and L. Multiflorum), and Fescue (Festuca spp.) Strains Adapted Particularly for Pastures in Maryland

Leaders: For the Maryland Agricultural Experiment Station -
W. B. Kemp.
For the Division of Forage Crops and Diseases, Bureau
of Plant Industry, U. S. Department of Agriculture -
P. R. Henson.
For the Pasture Research Laboratory - W. M. Myers.

ORCHARD GRASS

Collection of Material. Approximately 1,000 individual plants were established in the field to provide an additional source of material. These included progenies from 23 individual panicles collected from five local (Central Pennsylvania) sources and about 100 plants each of the strains Sl43, S26, Brage, Tammisto tall hay, Synthetic No. 1, and Synthetic No. 2. Synthetic No. 1 and No. 2 are temporary designations applied to the strains obtained from isolation of two groups of 10 selected clones (1940 Annual Report, Page 13).

Selection and Evaluation of Plants. Notes were taken at several times during the summer of 1942 on the plants of the original cooperative nursery (1940 Annual Report, Pages 12 and 13). The notes included earliness of spring growth, date of heading, plant type (whether leaves were basal, intermediate or carried well up on the flowering culms), leafiness, size of plant, height, width of leaf, profuseness of heading, leaf spot resistance, lodging resistance, selfed and open seed set, and recovery following mowing (the plot was mowed after the seed was harvested). On the basis of these data, 257 plants were selected which seemed superior in at least several of these characters. Date of heading ranged from May 15 to June 19 and the selected plants were divided into six groups on that basis. Each maturity group was subdivided further into pasture, intermediate, or hay type. The selected plants were divided vegetatively and planted in a replicated polycrossing plot, the plants within each maturity plant type group being distributed at random in each replication. Duplicate crossing blocks were planted at the B.P.I. Station, Beltsville, Maryland, and at the Pasture Research Laboratory, State College, Pennsylvania.

Strain Trials. Replicated plot trials of 27 single crosses of selected clones, six strains (Brage, Sl43, Tammisto Tall Hay, S26, Synthetic No. 1, and Synthetic No. 2), and three commercial seed lots were planted at State College, Pennsylvania, in the fall of 1942. The plots were arranged in a simple lattice design with four replications. A uniform seeding of Ladino clover will be made over the entire area in the spring. Observational plots of seed from commercial sources and of Synthetic No. 1 and Synthetic No. 2 were planted at the Maryland Agricultural Experiment Station in the fall of 1942.

New Strains. Using single crosses of selected superior clones, isolation plots were established in the fall of 1942 to produce seed of eight double crosses and one triple cross (combination of three single crosses).

Inbreeding Studies. The inbreeding program that is being conducted at the Pasture Research Laboratory has been summarized elsewhere (Page 17). In addition, an inbreeding program is being carried out at the University of Maryland Farm, Beltsville, Maryland. In the latter program, 2,300 plants of second inbred generation progenies were planted in the field in the spring of 1942 and notes on vigor, leafiness, and disease resistance were taken on these plants during the summer. In the two inbreeding programs, different parental materials were used; hence, the programs do not represent a duplication of effort.

PERENNIAL RYEGRASS

Two crossing blocks were set clonally from promising perennial ryegrass of diverse origin. Multiplication was begun of a promising strain obtained from an old homestead on Tilghman's Island in the Chesapeake Bay where the elevation is low and humidity high. This selection showed much evidence of disease resistance.

OVER-LIMING INJURY (WITH CONNECTICUT)

Title: A Study of the Causes of Over-liming Injury to Pasture Species.

Leaders: For the Connecticut (Storrs) Agricultural Experiment Station - B. A. Brown
For the Pasture Research Laboratory - R. R. Robinson and V. G. Sprague

The overliming study was continued this year (1941 Annual Report, Page 10). In one experiment leaf hoppers injured the alfalfa so severely that yields were not determined. Observations showed that the best early development of the alfalfa occurred on the overlimed cultures to which no minor elements had been added. However, these soon exhibited typical symptoms of boron deficiency. Some improvement was obtained by adding solutions of boric acid, but not as much as shown by moderately limed cultures which had received boron, alone or in combination, before planting. The other minor elements--Mn, Cu, Zn, and Fe--had little, if any, effect.

Alfalfa in pot cultures started in two different soils in 1941 grew as well in 1942 on overlimed as on moderately limed soil, but regardless of rate of liming, showed distinct symptoms of boron deficiency in 1942 where no borax had been added at time of planting. Thus, the overliming injury of 1941 was non-existent in 1942, while boron deficiency was much more pronounced.

Heavy liming of field plots has not caused any retardation of newly seeded alfalfa, but without borax, severe symptoms of boron deficiency were evident on both cuttings in 1942.

Another pot experiment was conducted in an attempt to determine whether phosphate and boron would correct overliming injury. For the first week or two after the alfalfa was seeded, overliming injury was observed, particularly at the low phosphate level. Topdressings of borax at the rate of 20 and 40 pounds per acre appeared to help; at 150 and 300 pounds it was injurious. At the end of one month the high phosphate series showed little if any overliming injury. In the low phosphate series there seemed to

be some injury, and boron did not appear to have had much effect in overcoming it. At the end of two months, when the crop was harvested, the high lime treatments gave higher yields than the medium lime treatments. Boron applications did not give increased yields. All of these results strongly indicate that overliming injury to alfalfa is not always connected with a deficiency of boron.

POA PRATENSIS BREEDING (WITH PENNSYLVANIA)

Title: Breeding Kentucky Bluegrass for Improved Pasture Types

Leaders: For the Pennsylvania Agricultural Experiment Station -
J. K. Thornton and S. I. Bechdel.
For the Pasture Research Laboratory - V. M. Myers.

Collection of Source Material. Because of travel restrictions, additional material was not collected except in central Pennsylvania, near State College. In connection with a survey of incidence of leaf smut in pastures in this area (Page 56), approximately 2,600 sod plugs were taken at random from 13 pastures. These will be transplanted to the field in the spring to provide material for further breeding work.

Progeny Uniformity Tests. A progeny uniformity nursery was established in the fall of 1942 consisting of 20 plants from each of 37 different plants which were selected as off-type from the 1940 nursery. Preliminary data on uniformity were taken on the progenies planted in the fall of 1941 (1941 Annual Report, Page 11).

Seed Increase. Seven hundred plants of each of five strains were set out in the spring of 1942 for seed increase. Two of these strains originated at the Pennsylvania State College and three at the Pasture Research Laboratory. In addition, smaller seed increase plots of 18 other strains were established in the fall of 1942. The latter increase plots were particularly to provide seed for more extensive testing of the strains.

Preliminary Plot Tests. Small (2' x 3') replicated plots of 28 new strains were established in the spring of 1942 and plots (3' x 5') of an additional 77 strains were planted in the fall of 1942. The seed of these strains was obtained from the selected plant progenies used for uniformity trials. In each test, check plots of two strains from the advanced plot tests were included at regular intervals. A uniform seeding of white clover was made over the entire area. These plots will be clipped uniformly with a lawn mower and observational data but not yields will be taken.

Advanced Plot Trials (Yield Tests). Clipping weights of total herbage were taken on the plots of 25 strains (1941 Annual Report, Page 12). Clippings were made at approximately 10 day intervals with the mower set at 1-1/4". Six of the strains compared favorably with the check plots in yield. Five of the strains have been discarded because of the extreme susceptibility to Helminthosporium leaf spot. It is planned to take records on these plots for at least one more year. In another advanced plot trial, 13 strains were used including four of the strains included in the test just discussed. Since this test is being conducted as a methodology study as well as a strain trial, the results are presented elsewhere (Page 19).

In the fall of 1942 replicated plots were seeded of four strains from the Uniform Grass Nursery and five new strains that have proven superior to date in the advanced plot tests described above. These plots will be clipped with a lawn mower and other data will be taken.

POA PRATENSIS AND TRIPOLIUM REPENS BREEDING
(WITH WEST VIRGINIA)

Title: Breeding and Improvement of Pasture Grasses and Legumes.

Leaders: For the West Virginia Agricultural Experiment Station -
E. J. Wallhausen, R. O. Weibel, J. G. Leach.
For the Pasture Research Laboratory - S. S. Atwood
(White Clover) and W. M. Myers (Kentucky Bluegrass).

Two hundred ten plants started from seed collected from various pastures in West Virginia and 242 plants started from sod plugs collected from old pastures on limestone areas in the Allegheny Mountains of West Virginia were added to the bluegrass observation nursery in 1942. In addition plants were established from plugs taken from pastures in Tennessee, bringing the total number of individually spaced plants under observation in the nursery up to approximately 4,800.

No additions were made to the white clover nursery. Many of the 1,000 individual plants previously established have died.

Most of the work in 1942 was devoted to a study of individual plants of bluegrass established in the observation nursery in 1940, from the standpoint of general vigor, type and disease. Three hundred twelve plants were selected for more detailed study. Seed harvested from these plants was seeded in small plots (3' x 12') in October with two replications of 182 of the most promising selections and single plots only of the others. White clover will be seeded on these plots early in 1943 in order to study the behavior of these strains in association with white clover.

A progeny test of 40 plants each from 240 individual plant selections made in 1941 were established in the field in the spring of 1942. Notes on the breeding behavior of these progenies will be taken in the spring of 1943. Progeny tests of strains selected in 1942 for further study will be started in 1943.

Since the individual plant nursery was made up of selections from both good and poor pastures, it offered an opportunity to compare types from the two sources. Pastures containing a good bluegrass sod in a good state of productivity were designated as good pastures. Pastures in which the predominating species were broomsedge and poverty grass with an occasional tuft of bluegrass were designated as poor pastures. In order to get some idea of the differences in yield and other characters, if any, 27 or 28 clones picked at random from each of the two kinds of pasture were brought into the greenhouse and established in eight-inch pots, three replications of each. Table 1 shows the distribution of average yields per pot from seven cuttings.

Table 1. Frequency distribution for average yields of clones from good and poor pastures.

Source	Class Midpoints (Grams)							Total	Mean
	0.75	2.25	3.75	5.25	6.75	8.25			
Poor Pasture	2	6	10	8	1	0		27	3.81
Good Pasture	0	3	10	12	2	1		28	4.53

The average yields of clones from a poor pasture ranged from a low of 0.88 grams to 6.35 grams per pot, with a mean of 3.81 and a median of 3.99. The yields of clones from a good pasture ranged from 1.76 to 8.03 grams per pot, with a mean yield of 4.53 and a median of 4.57. It is apparent that the population from the good pasture is higher yielding than the one from the poor pasture, the average difference per pot being 0.72 grams.

The relative resistance and susceptibility of the above clones to mildew is given in the 1941 report, Page 13, where it is shown that by far the majority of the clones from the poor pasture were susceptible to mildew, whereas the majority of those from the good pasture were resistant.

Rust readings taken on the same clones in the field in 1942 revealed a similar behavior with respect to rust.

Table 2. Resistance and susceptibility to rust of clones tested in greenhouse for yield. (Rust readings taken in field)

Source	:: Susceptible	:: Medium Susceptible	:: Resistant
Poor Pasture	:: 12	:: 7	:: 7
Good Pasture	:: 1	:: 8	:: 19

As evident from Table 2 by far the majority of those clones obtained from the poor pasture were susceptible to rust, whereas the majority of those from the good pasture were resistant.

This was generally true for clones from poor pastures. Out of 395 clones in the nursery that came from 12 different definitely poor pastures, 47 per cent were susceptible to rust in varying degree, whereas out of a total of 341 clones taken from 11 different good pastures, only 31 per cent were susceptible.

The most serious disease noted in the bluegrass nursery was stripe smut, caused by Ustilago striatiformis. Approximately 15 per cent of the plugs taken at random from different pastures throughout the state in 1940 developed smut when broken up and planted in the nursery. No doubt the plants that developed smut in the nursery were infected at the time they were brought in, although the infection was not noticed. Percentage infection in the different pastures on the basis of plugs taken ranged from 0 to 33 per cent. Since smut did not spread in the nursery like some of the other diseases, it could not be determined whether more of the strains obtained from poor pastures were susceptible to smut than of those obtained from good pastures. Direct observations in certain pastures, however, indicate that a high percentage of the types existing in poor pastures may be susceptible. In the nursery the highest percentage of infection was in plugs taken from a pasture in Greenbrier County in 1940. Before the application of lime and fertilizer seven years ago this pasture consisted mostly of broomsedge and poverty grass, with a few scattered tufts of bluegrass. By 1940, however, when the plugs were taken a good sod of bluegrass had developed. This pasture was visited again in June 1942 and found to be very seriously injured by smut. The pasture appeared as if suffering from severe drought, yet it had been generously supplied with rainfall. In certain

areas of this pasture 100 per cent of the turf was infected. On the whole, about 50 per cent of the turf showed severe infection and the carrying capacity was severely reduced.

Upon investigation of a large number of pastures throughout the state, it was found that no pastures were entirely free and in the one discussed above an estimate of 50 per cent infection would be conservative. Many plants had been killed and all infected plants were badly stunted.

The data obtained on the clones in the greenhouse with respect to yield are in general supported by observation of a larger number of clones in the field nursery. Individual clones in the field nursery that might be worth further testing were tagged in the spring of 1942. Selections were made primarily on the basis of general vigor and freedom from disease. However, few diseases were prevalent at the time so the selection really amounted to marking the vigorous plants. The tagged plants were further classified on the basis of fair, good and excellent vigor.

Out of a total of 395 clones established from 12 different poor pastures 13 per cent were classed as fair, five per cent as good, and one per cent as excellent; whereas out of 341 clones obtained from 11 different good pastures 21 per cent were classed as fair, eight per cent as good, and four per cent as excellent. This definitely shows that the chances of getting good vigorous types for an average level of fertility are much greater in good pastures than in poor pastures.

SNOW MOLD IN PASTURE AND FINE TURF GRASSES (WITH PENNSYLVANIA)

Title: Snow Mold in Pasture and Fine Turf Grasses.

Leaders: For the Pennsylvania Agricultural Experiment
Station - C. C. Wernham.
For the Pasture Research Laboratory - K. W.
Kreitlow.

Continuation of the work reported last year revealed that some of the winter injury of orchard grass in Connecticut may be due to an undescribed species of Typhula. Injury or killing of pasture grasses by Typhula snow mold is dependent on climatic conditions favorable for development of the

fungus. The more important pasture grasses of the northeast seem to be uniformly susceptible to Typhula infection but, for the most part, they are weakened rather than killed by the organism.

Field inoculations made in 1941 were unsuccessful probably because of the open winter. It is suggested that the method of artificial inoculation developed under this project may be used to select resistant varieties.

A paper summarizing the results of this investigation has been prepared for publication (Page 68).

TRIFOLIUM REPENS BREEDING (NEW JERSEY)

Title: Breeding White Clover for Pastures.

Leaders: For the New Jersey Agricultural Experiment Station -
G. H. Ahlgren.
For the Pasture Research Laboratory - S. S. Atwood.

Progeny Test of Diallel Crossing System. The materials and methods used in this study were described previously (1940 Annual Report, Page 15, and 1941 Annual Report, Page 14). A third block of progeny originating from diallel crossing was planted on June 3, 4, and 5, 1942. This group consisted of 38 crosses replicated three times. Each replication consisted of six individuals plus a check plant for comparison. A few of these plants have been lost due to field hazards. While all of the possible 190 crosses (omitting reciprocals) are not as yet replicated, it is felt that the test is complete enough so that adequate data to evaluate this breeding system can be obtained without making further crosses. A few of the crosses of plants numbered 6-1, 6-4, and 6-12 are still missing but nearly all of the others have been observed in at least one replication.

Notes were taken in 1942 on the 1941 and 1942 block plantings as follows:

1. General vigor.
2. General variability.
3. Leafiness.
4. Disease.
5. Spread of plant.
6. Height of petiole.

No superior progeny has been selected from these plantings as yet.

The original block planted in 1940 was plowed under in the spring of 1942. Superior plant selections based on notes and observation were selected and transplanted for further observation and, possibly, to use in further breeding work. Four parent plants known as 6-3, 6-9, 6-10, and 6-16 appeared the greatest number of times in relation to the outstanding crosses.

The 20 parent plants originally entering into the diallel crosses are being maintained for further use as soon as those giving superior combining ability have been determined.

Continuous Selection from Six Isolated Open-pollinated Strains. Seed has been harvested the past summer from the six superior giant type white clover plants which are being utilized in this breeding system. A fairly good quantity of seed is now available. It is hoped that this seed can be planted next spring for further testing and selection.

Drought Resistance Study. The first greenhouse test on white clover wilting made in 1941 was unsuccessful since the plants were too severely desiccated and all died. In the second test during 1942 the first wilting was not severe enough and none of the plants died. Using the same plants after complete recovery, a third wilting test is under way. Marked differences in resistance to extreme desiccation have been found in this later test. Over half of the plants have been destroyed to date. The crosses (Dil3Xl3-12) and (Dil3XLal4) as well as the parent plants are included in this study.

The method used is to permit the top growth of the clover plants to reach a height of six to seven inches. This growth is then entirely removed, leaving only the stolons. The jars are brought to a uniform weight by adding water and the desiccation process then initiated. The length of the drying period depends on climatic conditions. These periods have ranged from 10 to 30 days in this last test. The following notes are being taken:

1. Hours to wilting.
2. Length of time wilted.
3. Weight at wilting.
4. Green and dry weight of top growth.
5. Those recovering and those dead after desiccation period.

The wilting is judged by the new leaves which develop from the stolons soon after removal of the original top growth.

RESEARCH AT THE LABORATORY
CYTOGENETICS AND BREEDING OF GRASSES

Fertility Studies in Dactylis glomerata

Variation and Inheritance of Ability to Set Seed Under Bag.

The results reported previously (1941 Annual Report, Pages 16 to 18) have been published in two papers (Page 65). Investigations of ability to set seed under bag in orchard grass have been continued along three lines as follows:

1. The range in self-fertility among plants of strains, commercial seed lots, and collections from natural populations is being investigated.
2. The inheritance of self-fertility is being investigated further using plants of the I_2 (second inbred generation) from selected I_1 plants.
3. A preliminary study of the inheritance of cross-fertility is being made by diallel crossing of the F_1 plants from two self-sterile parents.

These investigations involved placing three parchment bags on panicles of each of well over 6,000 plants and, in addition, collecting one sample of four panicles from each plant for determination of open-pollinated seed set. This work was done during the summer of 1942, the panicles have been threshed, and the seed counting is nearly completed. Interpretation of the results must await the analysis of the data.

Inheritance of Male Sterility. For use in genetical investigations of the type of male sterility in which all or a majority of the F_1 of male sterile X male fertile are male sterile (1941 Annual Report, Page 19), crosses were made in the greenhouse in 1941-42 and in the field in 1942. Among the F_1 plants of three families which had the male sterile parent in common, two male fertile plants were each crossed with several male sterile F_1 's from each family. Two male sterile F_1 's from one family were crossed with all of the male fertile plants of that family. In a fourth family, with a different male sterile parent, two male sterile F_1 's were crossed with 12 male fertile F_1 's and two male fertile F_1 's were crossed with 12 male sterile F_1 's. In addition, all male sterile and male fertile F_1 's which were used in sib-matings were backcrossed to their male fertile and male sterile parents, respectively. From these crosses, plants of 133 F_2 progenies and 34 backcross progenies, totaling over 7,000 plants, were spaced in the field in the fall of 1942.

Varietal Improvement of Lactylis glomerata, Festuca elatior, Poa pratensis and Sorghum vulgare var. sudanense

Most of the investigations relating directly to the improvement of orchard grass and Kentucky bluegrass have been incorporated in the cooperative breeding projects with these species and the report of these investigations will be presented in that section of the Annual Report (Page 2).

Evaluation of Plant Types. The results obtained from strain trials of Kentucky bluegrass served to emphasize further the unreliability of observations of spaced plants for judging the behavior of the strain under conditions simulating grazing. Small plots seeded with strains of grass (1941 Annual Report, Page 19) and planted uniformly with white clover are being used for preliminary evaluation in the cooperative breeding project. In addition, somewhat larger seeded plots (3' x 5') are being used for this purpose. A comparison will be made of the behavior of strains in these preliminary plots with their behavior in subsequent tests as a basis for evaluating the reliability of results from the small plots.

Some evidence has been obtained indicating that the behavior of clones of orchard grass may not provide an accurate criterion of their breeding potentialities; that instead it may be necessary to resort to tests of combining ability in evaluating plants of this species for parental material. Diallel crosses have not proved to be a feasible method for this purpose. Too much labor is required to produce by hand pollination sufficient seed for replicated plots. On the other hand, establishment and maintenance of a number of isolation plots are difficult and expensive tasks. Consequently, investigations have been started of the polycross method, which involves use for testing of the seed produced on each selected plant by the random interpollination of all of the selected plants. This method is being used apparently successfully in the alfalfa breeding program. For this study, the plants selected in the cooperative breeding investigations (Page 6) are being used.

Inbreeding in *Dactylis glomerata*. The value of inbreeding as a tool in the improvement of the naturally cross-pollinated forage species has been much debated, there being a considerable weight of opinion opposed to it. Nevertheless, inbreeding by self-pollination provides the most rapid feasible method for fixing desirable characters in the homozygous condition. The answer to the general question is contingent

upon (1) whether sufficiently vigorous inbred lines can be produced and (2) what use can be made of the inbred lines if they are obtained. Such problems can be solved only by experimentation; hence a rather extensive inbreeding program is being conducted.

In the fall of 1941, 87 I_3 progenies from selected I_2 plants were established. Among these progenies there was a wide range in vigor; some were very nearly as vigorous as their parental clones; others were so weak that most of the plants failed to survive through the winter of 1941-42 or through the summer of 1942. In the fall of 1942, 30 plants of each of 260 additional I_3 lines were established in the field. In all cases, the parental, I_1 , and I_2 clones have been retained and planted in the rows adjacent to the I_3 progenies.

In the spring of 1942, an additional 40 I_1 progenies were established and, in the fall, 133 more were planted. These additional progenies will provide a wider genotypic basis from which to produce inbred lines.

Inbreeding Studies in *Sorghum vulgare* var. *sudanense*. The development of inbred lines was continued in 1942 by growing 403 rows each obtained from the selfed seed of a single plant grown in 1941. The lines varied from three to seven generations inbred. There were also grown for the first time 44 inbred lines obtained from Doctor R. E. Karper in Texas. Notes on amount of injury from leaf-spot were taken in September, and an attempt was made to obtain selfed seed on 177 rows selected as superior in regard to absence of disease and agronomic usefulness.

Natural Crossing in *Sorghum vulgare* var. *sudanense*. In 1941 two rows breeding true for absence of red pigment were grown in a block of plants mostly homozygous for red color. A head from a non-red plant was enclosed in a bag with a homozygous red colored head and of the 183 F_1 plants obtained from seed on the non-red plant 61 per cent were red, indicating crossing to that extent. From an open-pollinated head harvested from the same plant, 77 per cent of the 31 F_1 plants were red and must have come from crossing. A single open-pollinated head from the other non-red row yielded 76 per cent of its F_1 plants with red color.

Yield Trials of Inbred Lines of *Sorghum vulgare* var. *sudanense*. On the basis of notes taken in 1941, 69 inbred rows were selected as superior in regard to agronomic quality. Bagged seed from each of these rows together with seed of the Tift strain (F.C. 5329) was planted in three replicated rows in 1942, and during August and September the plants were cut off

four inches above the ground whenever they had reached a height of about 18 inches. At the last cut on September 15, all rows were cut irrespective of their heights. The total dry weights for the 70 strains were significantly different, but the differences between replications were not significant. The Tift strain, with a total yield of 724 grams dry weight for the three replications, outyielded all others. The next best strain yielded 606, whereas the average of all strains was 370, and the lowest was 149.

Significant differences also were obtained among the 44 Texas strains when they were clipped as described. A total of 615 grams was harvested from the best strain, the average of all strains was 419, and the poorest strain yielded only 113.

Method of Reproduction in *Poa pratensis*. Data were obtained from the second generation progeny tests described in the 1940 Annual Report, Page 18. The results were in agreement with those obtained previously from first generation progeny tests (1939 Annual Report, Page 14; 1940 Annual Report, Page 18), indicating a high incidence of sexual and partially sexual types in Kentucky bluegrass. The second generation tests showed that errors in classification were common in the first generation tests. Plants which were classified as parental types were shown by their progenies to be variant types and vice versa. The errors arose from the difficulty of distinguishing between variations conditioned by environment and those conditioned by heritable factors when dependence must be placed upon an individual plant. On the average, the variant type first generation plants had more variable progenies than their parental type sibs. Exceptions to this were found, however. One first generation plant from a highly sexual parent had only 3.3 per cent of variant types among its progeny. A paper summarizing these results was presented before the meetings of the American Society of Agronomy in November 1942, and has been submitted for publication (Page 65).

Strain Trials of *Poa pratensis*. Thirteen selected strains and two commercial seed lots of Kentucky bluegrass were planted in replicated plots in an experiment designed to measure relative yields of the strains when grown in association with white clover and simultaneously to study the effects of the different grass strains, clipping treatments, and environmental factors upon the incidence of white clover. Two clipping treatments were used, viz., (1) until July 1, plots clipped with the lawn mower set at 1/2 inch when plants averaged three to four inches in height, after July 1 plots clipped with the lawn mower set at one inch

when plants averaged four to five inches, (2) plots clipped throughout the summer with the lawn mower set at one inch when plants averaged four to five inches. A split plot design with four replications was used, the clipping treatments being the main plots, and the strains the sub-plots. The sub-plots were 3' x 9'. The plots were seeded in the fall of 1940, were clipped uniformly to control weed growth and to encourage establishment during 1941, and the yield determinations with differential clipping treatment were started in the spring of 1942.

For the purposes of the experiment, it was necessary to obtain an accurate measure of the percentage of bluegrass and white clover in each sub-plot at each clipping date. To accomplish this, a sampling method was devised and its reliability tested. Samples were taken by clipping, with hand-operated grass shears, narrow (about two inches wide) strips parallel with the long axis of the sub-plot, prior to cutting the yield strip with the lawn mower. The samples were larger than desired when the entire strip was harvested so the size of sample was reduced by alternately cutting and skipping four inch lengths along the sample strip. This provided a sample consisting of approximately 12 per cent of the total herbage harvested from the plot. The samples were separated when green, the separate parts were dried and weighed, and the percentages of bluegrass, white clover and weeds were calculated. To test the reliability of this method, three samples were collected from each sub-plot and the components of the error variance were compared using the relationship $K = \frac{np + q}{Nn}$ where

K = the variance of the mean for error

p = the estimated true variance between sub-plots within replications, i.e., the error mean square - $q/3$

q = the sampling variance, i.e., the variance within sub-plots

n = number of samples per sub-plot

N = number of replications

The sampling study was conducted at four dates of clipping and the results were strikingly similar at all dates. The value q was very low compared with p; hence, the sampling method may be considered reliable.

At two clipping dates, the percentage of clover was estimated with the inclined point quadrat. Using the sampling technique as a basis for comparison, it was found that the

point quadrat did not provide a reliable measure of the percentage of white clover in the plots. The results of the sampling study were presented at the meetings of the American Society of Agronomy in St. Louis (Page 65).

Yield data were taken by harvesting with a power driven lawn mower the herbage in one strip the width of the mower (18 inches) through the middle of the sub-plots and parallel with the long axis. The yield samples were oven dried and then weighed. The yields of bluegrass and of white clover were calculated from these data using the percentages determined from the sampling technique. Statistically significant differences among strains were obtained for total yield of herbage, yield of bluegrass, yield of white clover, and percentage of white clover at each date of clipping and in the totals for the season.

The relative rank of the strains at different dates of clipping in total yield of herbage and in yield of bluegrass changed very appreciably, indicating differential seasonal distributions of the herbage production of the different strains.

This is illustrated by the data presented in Table 3. The commercial seed lot designated Com. B was the higher yielding of the two, and all strain yields are presented in per cent of the yield of Com. B. Five of the thirteen new strains gave total yields as high as or higher than Com. B. The greatest increase was 14.6 per cent, not a very significant increase from a practical standpoint. A comparison of the distribution of yields throughout the season gives a more favorable picture for the new strains. At the first two clippings, the five new strains yielded less or only slightly more than Com. B. In the third clipping, three yielded slightly more (10 to 14 per cent increase) and two slightly less than Com. B. At the next three dates (July 21, August 19 and September 3), each of the five new strains yielded more than Com. B, the increase being as much as 93 per cent for one strain on September 3.

Differential seasonal distribution was shown also by three other strains (Table 3). The yield of 114 (12) compared fairly well with Com. B at the first two clippings, dropped to only 46 per cent on August 19, and then showed some recovery in the fall. Two strains, 162(95) and 139(111), although yielding lower than Com. B for the entire summer, were superior to it during July and August.

The data for calculated yield of Kentucky bluegrass showed relationships similar to those for total yield of herbage except that the differences between Com. B and the selected strains were slightly smaller. Some of the selected strains, in addition to their greater yielding ability, had higher percentages of clover in their plots.

The differential clipping treatments did not affect significantly the percentage of white clover at any time during the growing season. There was, however, a significant effect of clipping treatment on total yield of herbage, yield of bluegrass, and distribution of yield. The 1/2 inch clippings resulted in 25 per cent higher total yields for the year than the one inch clipping. An increased yield of 46 per cent was obtained for the three clippings made during May and June, when clipping at the 1/2 inch level removed a higher percentage of herbage from the plots than clipping at the one inch level. The close clipping noticeably affected the rate of recovery, however, so that the plots clipped at the one inch level were cut on July 21 and again on September 3 while the close clipped plots were cut only once (August 19) during this period. Both series of plots were cut again on October 19. The results of the 1/2 inch clipping suggest that such close and frequent clipping or grazing early in the season may be undesirable from the standpoint of obtaining high productivity during midsummer. None of the strain X clipping treatment interactions was statistically significant. It is planned to continue this experiment during 1943.

Collection of Material of *Festuca elatior*. In the past few years there has arisen considerable interest in the Northeastern Region in meadow fescue as a pasture grass. Consequently preliminary steps were taken to explore the possibilities of a breeding program in the improvement of this species. During the fall of 1941, 247 individual panicles were collected from 23 old pastures in central Pennsylvania and five plants were established in the field from each panicle. Considerable variation both between and within progenies was found among these plants in general vigor, rust resistance, leafiness, coarseness of growth, particularly width of leaf, date of heading, and other characters of probable agronomic value. Selections will be made of the more promising for further testing.

Genetical Investigations

Heritable Young Plant Characters in *Dactylis glomerata*.

During the winter of 1941-42, the I_1 progenies of 119 plants from open-pollinated populations were spaced in flats in the greenhouse and grown for about three months during which time the progenies were examined repeatedly for classifiable characters. Of the 119 I_1 progenies, 102 were segregating for one or more characters. From these progenies and from I_1 and I_2 progenies examined previously (1941 Annual Report, Pages 20 and 21), 31 phenotypically different chlorophyll deficiencies and growth abnormalities have been isolated. Each of these has been found in from one to 19 unrelated families. Those from different families may be conditioned by the same or different genes. Tests of allelism are now in progress.

In the case of the viable recessives, intercrosses are being made between similar recessive types from different families and from the F_1 's the presence or absence of allelism may be determined. In addition seed is being obtained from selfing or sib-mating of recessives of the same family to establish in each case whether the abnormality was conditioned by a heritable gene or by some environmental factor. In the case of lethal characters, such as albino seedlings, it is necessary to use heterozygous plants in the allelism tests. For this purpose simplex (A_1a_3) plants (1940 Annual Report, Page 21, for type of inheritance in orchard grass) from different families are being intercrossed. In crosses involving plants with the same allele, the F_1 will segregate three green:one albino while when different alleles are involved the F_1 will be all green. The simplex plants are also being used as testers for crossing with the duplex (A_2a_2). In such cases, ratios of 11 green:one albino are expected in F_1 if the same allele is involved in the two parents.

Inheritance of Disease Resistance in *Dactylis glomerata*. No further detailed studies of the inheritance of resistance to stem rust in orchard grass (1939 Annual Report, Pages 15 and 16) have been made largely because of the erratic ephytotic which was obtained. Observations that were made indicated that susceptibility was recessive and that a majority of orchard grass plants are immune or highly resistant to the pathogene.

During the summer of 1942 there was an extremely destructive ephytotic of *Stagonospora* leaf spot in the orchard grass nursery. The behavior of the inbred progenies indicated that susceptibility was recessive. Susceptible segregates were obtained among the progenies of resistant plants while the

progenies of susceptible plants were uniformly susceptible. In the cooperative breeding nursery (1940 Annual Report, Page 12) there were plants from seed collected from 22 pastures and seed fields in Maryland, Virginia and from seven localities in Pennsylvania. A great majority of these plants were highly susceptible but a number of outstanding exceptions were selected. On the average, more resistance was found among the plants of the introduced strains, particularly S37, S143, Swedish Select Grazing, Roskilde, Akaroa, and Tammisto.

The inheritance of resistance to mildew was studied using I_1 and I_2 progenies of three families. The young plants were grown in flats in a greenhouse in which high humidity was obtained by release of steam. A satisfactory epiphytotic developed without inoculation. The results were consistent in general with the hypothesis of a single dominant factor conditioning resistance. Some discrepancies were observed, however, and these are being investigated further.

Cytological Investigations

Meiotic Behavior in Autopolyploids. Several of the perennial species of forage grasses behave cytogenetically as autopolyploids. Among these are orchard grass and timothy, important species of the Northeastern Region. Autopolyploids are, in general, irregular in meiosis, the irregularities resulting in reduced fertility and in the occurrence of aneuploids (plants with more or less than the normal number of chromosomes). In consequence, the plant breeder working with an autopolyploid species needs information regarding the relative importance of the irregularities found at different stages of meiosis, their causes, the relationships among them, and the possibilities of eliminating or reducing them by selection. During the past few years, these problems have been studied at the Laboratory in orchard grass, timothy and colchicine induced autotetraploid perennial ryegrass. The results have been summarized in this and earlier Annual Reports and in several journal papers. Figure 1 is presented to serve as a background for the discussion of these investigations which follows in this report.

The autopolyploid differs from the diploid or the allopolyploid in that it has three or more instead of two chromosomes of each kind. At prophase, therefore, there are more than two chromosomes synapsing in pairs at random and, at diakinesis and metaphase I, there are multiple chromosomal associations. In timothy, a hexaploid, there may be, at diakinesis, bivalents (Figure 1, A) or various combinations of bivalents, quadri-valents and sexivalents (Figure 1, B and C). In orchard grass,

an autotetraploid, the association at diakinesis (Figure 1: D, E and F) may vary from fourteen bivalents to seven quadrivalents, with occasional univalents (Figure 1, E) and trivalents. These associations of more than two chromosomes also are found at metaphase I (Figure 1: G, H and I, tetraploid perennial ryegrass) where in some species at least they are a source of irregularity because of the tendency for unequal distribution of the chromosomes at anaphase I. A quadrivalent in which the members are disjoining three to one pole and one to the other is shown in Figure 1, G and also in Figure 1, L. In orchard grass, on the other hand, such unequal distribution of quadrivalents has been found to be of minor importance. In this species, the presence of univalents at metaphase I (Figure 1: G, H, I and K) is the principal cause of aneuploid gametes, hence it is the more important irregularity. These univalents may be outside of the spindle near the poles (Figure 1, I) in which case they usually remain in this position at anaphase I (Figure 1, M). Usually, however, the univalents lie on the equatorial plate (Figure 1, K) or near it; in these cases they divide longitudinally at anaphase I (Figure 1, O and P). Part of the daughter univalents from the longitudinally dividing chromosomes are left in the cytoplasm at telephase I and the remainder are included in the daughter nuclei. The latter tend to lag at anaphase II and part of them are left in the cytoplasm as micronuclei (Figure 1, Q).

Meiotic Behavior in *Phleum pratense*. The results reported previously (1941 Annual Report, Pages 21 and 22) have been prepared for publication (Page 65) and the investigations are being continued particularly in the analysis of the interrelationships among the various features of meiosis. For these studies, microsporocyte material was collected from four replications of each of 20 clones of timothy. The cytological analysis has not yet been completed.

Meiotic Behavior in *Lolium perenne*. Studies of the progenies from sib-matings of F₂ plants and from backcrosses of the F₂'s to the asynaptic parent (1941 Annual Report, Pages 22-23) substantiated the hypothesis of a single major factor plus modifiers conditioning partial asynapsis. The results also indicated that expression of the asynaptic character was greatly influenced by environmental fluctuations.

Cytological Analysis of Triploid *Lolium perenne* and Its Open-pollinated Progeny. Investigations of the triploid perennial ryegrass plant have been continued (1940 Annual Report, Page 22, and 1941 Annual Report, Pages 24 and 25). At midprophase of the triploid, there was a preponderance

of paired and a deficiency of single chromosome lengths compared with the expected 1:1 ratio. This was interpreted as resulting from association of non-homologous segments both within and between chromosomes. The results at metaphase I indicated that non-homologous pairing was not accompanied by chiasma formation, at least in most cases. Of 165 metaphase I sporocytes observed, 41.5 per cent had seven trivalents (7_{III}), 32.3 per cent $6_{III} + 1_{II} + 1_I$, 19.5 per cent $5_{III} + 2_{II} + 2_I$, 4.9 per cent $4_{III} + 3_{II} + 3_I$, and 1.8 per cent $3_{III} + 4_{II} + 4_I$. No configurations other than trivalents, bivalents, and univalents were observed. Also, the total of bivalents plus trivalents equaled seven in all observed cases. Of the univalent chromosomes observed, 71 per cent were oriented on the equatorial plate, 24 per cent near the plate, and five per cent near one of the poles. The regular orientation of univalents in this material differs from the commonly reported behavior of unpaired chromosomes.

At anaphase I, there were 133 lagging and dividing chromosomes per 100 sporocytes compared with 93 univalents per 100 sporocytes at metaphase I. Among 100 anaphase I chromosome groups in which an accurate determination was possible, there were five with seven chromosomes, 11 with eight, 25 with nine, 32 with 10, 14 with 11, seven with 12 and six with 13. The data on chromosome loss, measured by the incidence of micronuclei in the quartets, indicated that (1) part of the daughter univalents from anaphase I laggards were included in the microspore nuclei and (2) that some micronuclei were formed due to abnormality of the second division itself.

Table 4. Numbers and percentages of plants with indicated chromosome number among the open-pollinated progeny of the triploid plant of perennial ryegrass.

	Chromosome Number					
	$2x/1$	$2x + 1$	$2x + 2$	$2x + 3$	$2x + 4$	Total
Number of plants	30	52	27	6	4	119 ^{/2}
Per cent of determined plants	25.2	43.7	22.7	5.0	3.4	100
Per cent of total plants ^{/3}	23.1	40.0	20.8	4.6	3.1	91.5

^{/1} $2x = 14$, $2x + 1 = 15$, etc.

^{/2} Total of plants of which the chromosome numbers were determined.

^{/3} Total plants (130) including those that died.

From pollination of the triploid with pollen from diploid plants, 152 seeds, and, subsequently, 130 seedlings were obtained. Eleven of the seedlings were very abnormal in appearance and died before chromosome number determinations could be made. The chromosome numbers of the remaining 119 plants are shown in Table 4. Comparison of the frequencies of different types obtained with those expected from chromosome distribution at anaphase I reveals an excess of $2x$ and $2x + 1$ types and a deficiency of types with two or more extra chromosomes. Part of the discrepancy probably resulted from the lower viability of the aneuploid macrogametophytes and embryos compared with the euploid. This lower viability resulted in greatly reduced fertility of the triploid compared with diploid plants. This relationship is interesting in consideration of the correlation of meiotic irregularity with fertility in orchard grass (Page 25). The results obtained with the triploid plant and its progeny have been prepared for publication (Page 65).

Comparative Cytology of Diploid and Induced Autotetraploid *Lolium perenne*. The investigations of meiotic behavior of diploid and induced autotetraploid perennial ryegrass clones obtained from the same seeds following treatment with colchicine (1941 Annual Report, Pages 23 and 24) have been continued for the purpose of obtaining replicated data from which a legitimate estimate of error may be determined. The cytological analyses are not yet completed.

In order to obtain clonal material for morphological, physiological and chemical studies of the effects of chromosomal reduplication, vegetative increases were made of the $2x$ and the $4x$ clones from chimeral seedlings which were obtained by seed treatments with colchicine (1938 Annual Report, Pages 33 to 37). Each clone was subdivided into single tillers which were space planted to produce new plants. This process of single tiller propagation was repeated twice and, at that time, it was discovered that the supposed $2x$ and $4x$ clones were in reality each still mixtures of $2x$ and $4x$ tissue. One plant from each clone was selected and subdivided into single tillers which were planted individually in three inch pots. Two root tips were taken from each new plant for determination of chromosome number. This process of single tiller propagation has been continued through six vegetative generations; the pot selected for production of the next generation always was one in which both root tips were either $2x$ or $4x$, depending upon which clone was involved. Furthermore in the fourth, fifth and sixth generations, three plants were subdivided to provide the new progenies and in each clone the plants selected for propagation of the next generation were from the progeny which seemed most nearly pure. In the fifth generation, both $2x$ and

4x clones from eight original plants were pure diploid and tetraploid, respectively. From two plants the 2x clones were pure while the 4x clones still showed some mixture both in the fifth and sixth generations and from two other plants the 4x clones were pure while the 2x clones still showed some mixture.

These results suggest that the colchicine treatment resulted in chromosome doubling only in part of the cells and that the normal and doubled cells were intimately mixed together. In addition, the results indicate that the growing points from which new tillers are produced in perennial ryegrass are developed by the differentiation of a group of cells instead of a single cell. Caution must be observed in the establishment of tetraploid clonal lines following colchicine treatment to be certain that such lines are not mixtures.

Meiotic Irregularity in *Dactylis glomerata*. In a series of cytological and genetical investigations, it has been demonstrated conclusively that orchard grass behaves cytogenetically as an autotetraploid ($x = 7$) and that plants of this species exhibit the meiotic irregularity characteristic of autotetraploids. Hence, the problem of meiotic behavior in orchard grass is of prime importance in the varietal improvement program. During the past few years investigations of this problem have been conducted (1941 Annual Report, Pages 25 and 26, and earlier reports). In 1942, additional data were collected and the available data were analyzed.

The analysis of covariance was used for studying the interrelationships among the meiotic characters investigated in the nine replicated parental clones (1941 Annual Report, Pages 25 and 26). The correlation coefficients obtained are presented in Table 5. Chiasma frequency was positively correlated with quadrivalent frequency and negatively correlated with incidence of metaphase I univalents. Quadrivalent frequency was correlated neither with incidence of metaphase I univalents nor with lagging at anaphase I. Metaphase I univalents were closely correlated with anaphase I laggards which in turn were closely correlated with incidence of micronuclei in the quartets.

From errors of estimate, it was determined that in all but one analysis of covariance there were significant differences among clones in the dependent variable which were independent of its relationship to the other variable. The single exception was in the covariance of metaphase I univalents with anaphase I laggards.

Only 2.5 per cent of the anaphase I sporocytes had other than a 14-14 distribution, indicating that unequal distribution of the chromosomes of the quadrivalents was not a major factor conditioning the production of aneuploid gametes in orchard grass. On the other hand, unpaired chromosomes at metaphase I which lag and divide at anaphase I would be an important factor in that regard. Quadrivalent frequency was not correlated with incidence of metaphase I univalents. Hence, variations in frequency of metaphase I univalents provided a more reliable criterion of meiotic regularity in this material than variations in quadrivalent frequency. Two of the nine clones had averages of three per cent of metaphase I sporocytes with univalents and, consequently, may be considered as relatively regular.

Table 5. Correlation coefficients calculated from the indicated analyses of covariance.

		: A with	: A with	: B with	: B with	: C with	: D with
Variance:	: $B/1$	: $C/1$	: $C/1$	: $D/1$	: $D/1$	: $E/1$	
Due to :D/F:	r	r	r	r	r	r	r
Clones	: 7	: 0.517	: -0.601/2	: 0.053	: 0.078	: 0.969/3	: 0.928/3
Error	: 15	: 0.041	: -0.037	: -0.192	: -0.252	: 0.363	: 0.176
Total	: 25	: 0.462/3	: -0.576/3	: 0.028	: 0.026	: 0.861/3	: 0.758/3
	:	:	:	:	:	:	:

- /1 A = half-chiasmata per chromosome.
 B = number of quadrivalents per sporocyte.
 C = percentage of metaphase I sporocytes showing univalents.
 D = percentage of anaphase I sporocytes showing laggards.
 E = percentage of quartets showing micronuclei.

- /2 = Exceeds r for P of 0.10
 /3 = Exceeds r for P of 0.01

Data on meiotic regularity were collected from 83 I₁ (first inbred generation) plants from eight families. The average frequencies of metaphase I univalents of the inbreds were two to three times greater than the averages of their parental clones. The average quadrivalent frequencies of the inbreds were the same as their parents in six families and higher in two families. Thus inbreeding resulted in an increase in all families in the most important feature of meiotic irregularity. This fact is of considerable interest in relation to the reduction in fertility found to accompany inbreeding in this species (1941 Annual Report, Pages 16 to 18). That this was not merely a

chance relationship is indicated by the significant negative correlation coefficients obtained within inbred progenies between the features of meiotic irregularity and fertility (Table 6).

Table 6. Average values of r obtained within inbred progenies between characters of meiosis and seed set.

Meiotic Character	Seed Set	
	Selfed	Open
	r	r
Quadrivalent Number	-0.12(42) ^{/1}	-0.31(34)*
% III univalents	-0.37(42)***	-0.37(34)**
% AI univalents	-0.40(42)****	-0.41(34)***
% micronuclei	-0.44(42)****	-0.40(34)***

^{/1} Number in parenthesis is degrees of freedom

* = r exceeds r for P of 0.10

** = r exceeds r for P of 0.05

*** = r exceeds r for P of 0.02

**** = r exceeds r for P of 0.01

The average correlation coefficients between characters of meiosis among plants within inbred progenies were similar in magnitude in most cases to those obtained between these characters among the parental clones. The exceptions involved the relationship of quadrivalent frequency with incidence of metaphase I univalents and, hence, with anaphase I laggards and micronuclei in the quartets. Quadrivalent frequency was not significantly correlated with the latter characters in the parental clones but within the inbred progenies the average values of r were -0.37($P < 0.01$), -0.34($P < 0.01$), and -0.26($P < 0.05$).

The absence of significant correlation coefficients for these characters among the parental clones and their presence among plants within inbred progenies result from the complex interrelationships of chiasma frequency, quadrivalent frequency and incidence of metaphase I univalents. These interrelationships have been discussed in a paper which has been prepared for publication (Page 65).

The increased incidence of metaphase I univalents that results from inbreeding may be accounted for in part by decreased chiasma frequency. However, the results showed clearly that decreased chiasma frequency was neither the only factor nor, in fact, the most important factor in that regard. The increased frequency of metaphase I univalents could have resulted from the segregation of chromosomal rearrangements in the inbred progenies. This hypothesis with supporting evidence has been presented in a paper prepared for publication (Page 65).

Chromosome Numbers in *Festuca elatior*. There have been reported in the literature, races of *Festuca elatior* with 14 (2x), 28 (4x), 42 (6x) and 70 (10x) chromosomes. The tetraploid, hexaploid and decaploid races have been reported only from Europe; all published reports of collections from natural habitats in the United States have given the chromosome number of 14 for meadow fescue. In connection with the breeding program, 247 single panicles from different plants were collected from 23 pastures and other local habitats in central Pennsylvania. One seedling from each panicle was planted in a three inch pot in the greenhouse and the chromosome number of each resulting plant was determined from root tip preparations. All plants were diploid ($2n = 14$).

Cytological Studies in *Sorghum vulgare* var. *sudanense*. Chromosome numbers and configurations were analyzed in open-pollinated progeny of three triploid plants by making smears of the microsporocytes. The frequency of the various chromosome numbers found was as follows: $2n$, 57; $2n + 1$, 60; $2n + 2$, 8; $2n + 3$, 2; $2n + 4$, 1. The extra chromosomes paired as trivalents in about half of the cells and were present as univalents in the others.

CYTOGENETICS AND BREEDING OF LEGUMES

Fertility Studies in *Trifolium repens*

Genetics of Self-compatibility. Studies of the S_f allele (1941 Annual Report, Page 27) have been continued to solve the following problems, all of which have a practical bearing on the use of this factor in a breeding program: (1) When a $S_f S_x$ plant is crossed either as male or female with a plant bearing two other alleles, do equal numbers of the two sorts of gametes function; (2) when a $S_f S_x$ plant is crossed either as male or female with a self-incompatible plant bearing S_x , does the S_x pollen function; (3) can $S_f S_f$ plants be found, what is their frequency, and what is the best source; (4) what is the nature of the modifying factors causing poor seed set in plants bearing S_f ; and (5) what are the factors influencing

autogamy? In order to answer these questions, appropriate crosses were made and the hybrid progeny grown in 1941. Selected plants were tested in the greenhouse last winter, and all plants involved in the study were bagged in the field last summer. Some of the results obtained in the field, however, were not definitive, so all questionable plants are being retested in the greenhouse this winter. A paper presenting preliminary results of this study has been published (Page 65).

Alleles Causing Cross-incompatibility. In previous studies of the number of oppositional alleles (1941 Annual Report, Page 28), plants from widely separate localities were used; a paper presenting these results has been published (Page 65). As a continuation of this investigation the plants collected from two locally-confined natural populations were crossed last winter with a single plant homozygous for incompatibility factors, and the F_1 populations were grown in the field last summer. Diallel crosses will be attempted among selected F_1 plants to obtain a measure of the proportion of alleles that are different in each population.

Additional evidence regarding the number of alleles in unrelated plants was obtained incidentally in two crosses being studied for inheritance of marker characters. In both cases, four intra-sterile, inter-fertile groups were found indicating that the parents of each cross had no alleles in common.

"Natural crossing" by Bees. The eight clones which were caged previously (1941 Annual Report, Page 28) were used in 1942, three of them being caged in triplicate. These clones differed significantly in degree of pseudo-self-compatibility as measured by the selfed seeds set following manipulation under bag, and all were recessive for the two marker characters used (purple leaf and V-shaped white area on the blade). In each cage, four cuttings of one of the recessive clones were enclosed with four cuttings of a clone homozygous dominant either for purple leaf or V-shaped white area on the blade. Seed was harvested from the recessive parents, and a total of 23,124 seedlings (for the two years) was classified. The per cent crossing ranged from 85.0 to 100.0 for different cages, and the eight clones were significantly different. A slight but not significant inverse relationship appeared to exist between the degree of pseudo-self-compatibility and the amount of crossing. Increased precision was gained when the per cent crossing was adjusted by covariance according to number of seeds per head or per cent germination.

In addition to the pseudo-self-compatible clones, one with a high degree of true self-compatibility ($S_f S_x$) was caged in 1942. In this case only 18.8 per cent crossing was obtained, but several lines of evidence suggested that under some conditions higher amounts of crossing would be expected for this clone. Since such widely different amounts of crossing are obtained within the species, it is evident that all clones should be investigated thoroughly at least for their self-compatibility before including them in the breeding program. A paper presenting these results has been submitted for publication (Page 65).

Effect of Naphthalene Acetic Acid on Incompatibility. Several hundred heads on 11 plants ranging from self-incompatible to highly pseudo-self-compatible were treated with Naphthalene acetic acid either dissolved in an aqueous spray or suspended in lanolin paste. The spray was applied both before and after pollination and either with or without removing the petals. The lanolin suspension was applied to the pedicels, to the ovary, and to the style, with and without removing the calyx and corolla and with and without a subsequent head treatment. Concentrations from one to 100,000 p.p.m. were tried, but in no case was the seed set increased significantly over the controls. With most treatments a sharp reflexing of the pedicels was observed (a movement which is ordinarily associated with normal fertilization and embryo growth), and with several of the more concentrated applications a normal sized but parthenocarpic ovary was developed.

Varietal Improvement of Trifolium repens

Inbreeding Studies. The 1942 inbreeding nursery consisted of 90 third-generation and 90 second-generation inbred lines, each planted in three randomized blocks with about 30 plants to a line. Wherever clones were available, those of the original parents, I_1 and I_2 were inter-planted with the inbreds. Although no detailed notes will be taken until next year, it was obvious that all lines were reduced in vigor but that some were reduced less than others.

About 6,000 heads were bagged to obtain selfed seed from inbred plants grown in the 1941 nursery. Probably due to the more than average amount of rain during the pollinating and seed ripening period, the seed set was lower in general than in previous years. Enough seed was obtained in most cases to perpetuate the lines, but often it was secured from the less desirable plants.

After plants homozygous for S_f were identified by a progeny test in the greenhouse last winter an attempt was made to obtain F_1 progenies by crossing one of these plants with each of the 100 plants being tested in sod plots (next paragraph). Only 71 of the plants flowered, but crossed seed was obtained on each of those, and the F_1 progenies were grown in the field last summer. The F_1 plants will be selfed as a source of new inbred lines to test the practical value of using the S_f gene to facilitate inbreeding.

New Sod Plots. The plots started in 1941 from 100 selected plants (1941 Annual Report, Page 30) were clipped with a lawn mower seven times during the summer of 1942, and the clippings were left on the plots. Estimations were made four times (late May, late June, late July, and early September) of the per cent clover, the averages obtained for the season ranging from 67.2 to 1.2 with a grand average for all plants of 24.7. The differences between these plants were highly significant and provided a basis for selecting the better ones in respect to their ability to grow with bluegrass. It was also observed that the better strains tended to rank in much the same order at the four note-taking periods. In addition to continuing these plots at least for another year it is planned to establish other plots from the 25 better clones for a more comprehensive test of their ability to grow with bluegrass.

Combining Ability of Sod-plot Selections. Notes similar to those just described were taken on the plots established from seedling F_1 plants obtained by crossing parents selected as good, medium, and poor yielders in the 1938 experiment (1941 Annual Report, Page 30). It is evident from Table 7 that there were significant differences throughout the season as well as for the type of parent.

Table 7.- Average per cent clover in plots established from F_1 seedlings derived from parents of different yielding ability.

Yield of Parents	May	June	July	September
High	31.8	57.8	55.9	69.9
Medium	23.2	51.4	53.2	63.6
Low	13.5	32.3	37.8	51.7

Ladino Clover Collections. The 1,430 plants of Ladino clover grown from the seed collected in the Northeast during 1940 (1941 Annual Report, Page 30), were noted three times in respect to their general vigor and prevalence of disease, and 327 of them were selected for vegetative increase and planting in plots next summer.

During 1942 seed was collected from 18 widely scattered Ladino pastures in South-Central and Eastern Pennsylvania, and cuttings were started from 407 plants growing in 17 of these fields. In addition, seed was sent in by cooperating agronomists from 11 fields in six other states of the Northeastern Region. It is planned to use this material principally as a source of breeding stocks.

Genetical Studies in Trifolium repens

Marker Genes. Studies of several mature plant characters were continued in the greenhouse last winter by making F_1 intercrosses and backcrosses of both F_1 and F_2 plants. Most of the resultant progenies will be classified next summer in the field.

A test for linkage between the oppositional alleles causing incompatibility and each of four leaf marking genes was made by crossing plants homozygous for the incompatibility factors with unrelated males bearing the appropriate leaf marking. F_1 plants that showed the leaf marking were then backcrossed as males to their female parent, and the resulting offspring were classified in the seedling stage. The segregations are shown in Table 8.

Table 8. Segregations in tests for linkage with incompatibility alleles.

Character	:	Marked	:	Unmarked
V-shaped white marking	:	143	:	157
White inside V-marking	:	277	:	267
Purple leaf	:	162	:	149
Red stripe	:	116	:	127

In each case the chi-square test showed a satisfactory fit to 1:1 ratio, indicating no linkage.

Segregation for V-shaped white on the leaf blade also occurred in the F₂ population studied for HCN (next paragraph), but no linkage was found between the leaf marking gene and those for glucoside and enzyme.

Inheritance of a Cyanogenetic Glucoside and Its Enzyme. From hybrid material started in the greenhouse last winter (1941 Annual Report, Page 31), segregation for glucoside and for enzyme was obtained in both F₂ and backcross generations (Table 9).

Table 9. Segregation for glucoside and enzyme.

Generation	Number of Plants with			
	Both	Enzyme	Glucoside	Neither
	Enzyme	but	but	Enzyme
	and	no	no	nor
	Glucoside	Glucoside	Enzyme	Glucoside
6 F ₂ families	101	42	36	10
10 B families	130	122	32	48
3 B families	53	42	-	-

These results were interpreted to mean that the presence of glucoside and of enzyme were each conditioned by a single dominant factor and that one of the original parents was heterozygous for the enzyme factor and homozygous recessive for the glucoside gene, the other parent being homozygous dominant. The chi-square test showed satisfactory fit to expected on this hypothesis for most families and for the totals. Most of the evidence indicated no linkage between these two factors.

The data from all families previously tested for HCN (1940 Annual Report, Page 27, and 1941 Annual Report, Page 31) have been reanalyzed on the two factor hypothesis, and satisfactory fit to expected was obtained in each case. The complete results of this study have been submitted for publication (Page 65).

Genetics of Rust Resistance. There were planted in the 1942 nursery, 1,069 plants derived by backcrossing 30 F₂ plants to their respective parents. Clones of the susceptible parent were inter-planted in this area in an attempt to induce a natural epiphytotic so that segregation with respect to host reaction to rust can be studied next summer.

Cytological Studies

Chromosome numbers were counted in root tips of the open-pollinated progeny from triploids of red, alsike and sweet clover. The frequencies of the various aneuploid and euploid types are shown in Table 10.

Table 10. Frequency of chromosomal types obtained in open-pollinated progeny of triploids

	Number of plants with following chromosome numbers					
	2n	2n + 1	2n + 2	2n + 3	3n	4n
Red clover	78	70	8	1	1	
Alsike clover	74	47	4			
Sweet clover	30	32	7			2

Although some of the aneuploid types showed distinctive vegetative characters, it was not possible to classify all of the plants into groups on the basis of these characters. It appeared that the parent plants were heterozygous and that after open-pollination, the characters resulting from extra chromosomes could not be distinguished from those which resulted from regular segregation and recombination.

In the fall of 1941 cuttings were taken from seven pairs of 64 and 32 chromosome slips, each pair having been derived from the same original colchicine treated white clover seedling. Chromosome counts obtained from root tips grown in the greenhouse showed that the 64 and 32 numbers had been maintained in each case. When 35 heads from five of the 32 chromosome slips were selfed last winter in the greenhouse, an average of 0.11 seeds per head was obtained. Likewise when 30 heads from six of the 64 chromosome slips were selfed, 0 seeds were obtained. Apparently with white clover, doubling of the chromosome number does not induce self fertility as has been reported for some other species. All of the 32 x 32 crosses which were tried proved compatible, and almost as good seed set was obtained from the 64 x 64 crosses that were attempted. With the 38 heads used in 64 x 32 crosses, however, only 0.29 seeds per head were obtained, and the 67 heads used in 32 x 64 crosses, the average seed set was 0.51.

On the hypothesis that a few pollen grains on the stigma of a pseudo-self-compatible plant might cause less inhibiting action than many and therefore have a better chance of effecting fertilization, an attempt was made to place only five to 10 pollen grains on a stigma by using a fine glass rod to carry the pollen and by applying the pollen while observing the stigma under a binocular microscope. From seven heads selfed in this way, no seed was obtained, while from two heads crossed in this manner, 41 and 16 seeds, respectively, were obtained. Since this plant continued to show pseudo-self-compatibility at this time either when pollinated with a toothpick or when manipulated, it is concluded that factors other than number of pollen grains on the stigma influence ability to set some selfed seeds.

PHYSIOLOGY AND COMPOSITION OF PASTURE PLANTS

The Preconditioning Effects of the Fall Environment on Subsequent Heading of Lectylis glomerata and Poa pratensis in the greenhouse

It is known that some species, meadow foxtail, for example, lay down floral initials in the field during the short days of the fall (1937 Annual Report, Page 32) whereas orchard grass and Kentucky bluegrass are not known to do so. Earlier work (1938 Annual Report, Pages 44 to 48) suggested that a certain length of time in the field is required to precondition the plants before floral primordia will be initiated when they are placed under a 16-hour photoperiod in the greenhouse. Further it has been shown (1941 Annual Report, Page 38) that in the greenhouse a period of short days is required previous to the 16-hour photoperiod in order to initiate heading in orchard grass.

In the present study the length of time required under field conditions during the fall and winter to precondition two grass species to head when subjected to a 16-hour photoperiod in the greenhouse was determined. The material used consisted of five clones of orchard grass and four clones of Kentucky bluegrass. Clonal tillers were started in four inch pots in August 1941 under a 16-hour day, the supplementary light being furnished by Mazda lamps at an intensity of about 75 foot candles. On October 7, these plants were transplanted to the field and so arranged that a sample consisting of eight pots of each clone could be brought into the greenhouse at approximately monthly intervals during the winter. After removal to the greenhouse, three pots of each clone were placed under a 10-hour photoperiod, three under a 16-hour photoperiod, and the tillers from the remaining two pots were dissected to determine the character of the growing point, whether vegetative

or reproductive, at the time the plants were taken from the field. To evaluate the effects of the duration of the field environment, three pots of each clone were allowed to remain in the greenhouse under a 16-hour photoperiod throughout the winter. These latter plants produced abnormally long leaf blades and long erect sheaths but in no case did any of them head. The results of the other treatments are presented in Table 11.

The following conclusions may be drawn:

1. Both orchard grass and Kentucky bluegrass clones used required a period of growth under a short photoperiod, low temperature or both, prior to a long photoperiod in order to initiate heading.
2. Clones within each species vary widely in the duration of preconditioning period required to initiate heading and, in general, with an increase in the duration of this period, the number of heads produced is increased.
3. With orchard grass, at least 51 days and preferably several weeks longer under the field environment was required to produce satisfactory heading on most clones. Number 11(11) was selected for this study because it had never headed previously in the greenhouse and heads only very sparsely when grown in the field. In this trial it required 135 days in the field before heading could be induced under a long photoperiod in the greenhouse.
4. No reproductive growing points were found in the field on the orchard grass until vegetative growth had actively begun in the spring. In the case of Kentucky bluegrass, however, clones had vegetative growing points at the end of 51 days in the field; but at 79 days reproductive stem tips had developed on two clones. The soil was frozen during this time.
5. In no case did orchard grass head under a 10-hour photoperiod. In this respect Kentucky bluegrass responded quite differently. The above data indicate that this latter species responded to long days in the greenhouse after two to three months in the field, but that after a longer period under a fall and winter environment, it headed in the greenhouse under a short photoperiod.

Table 11. Heads produced by orchard grass and Kentucky bluegrass in the greenhouse during the winter after various lengths of time in the field.

		Average number of heads per pot*																			
		16-hour photoperiod in greenhouse					10-hour photoperiod in greenhouse														
		Orchard grass - Clone No.																			
		20(16)		48(280)		12(7)		11(11)		20(16)		48(280)		12(7)		11(11)		NH(2)			
Oct. 31	25	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Nov. 26	51	4.0	1.7	0	0	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0		
Dec. 24	79	6.7	3.7	0	0	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Jan. 21	107	4.7	3.0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0		
Feb. 18	135	6.0	4.3	0.7	0.7	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0		
Mar. 18	163	4.3	6.0	4.3	1.0	4.0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Apr. 29	205	All clones with reproductive growing points**										0	0	0	0	0	0	0	0	0	
		Kentucky bluegrass - Clone No.																			
		140(11)		135(131)		2(10)		95(4)		140(11)		135(131)		2(10)		95(4)					
Oct. 31	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Nov. 26	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Dec. 24	79	0.3	2.0	11.7	r**	3.0	r	0	0	0	0	0	0	0	0	0	0	0	0		
Jan. 21	107	6.7	3.7	8.3	r	3.3	r	0	0	0	0	0	0	0	0	0	0	0	0		
Feb. 18	135	6.7	10.0	12.7	r	13.0	r	0	0	0	0	0	0	0	0	0	0	0	0		
Mar. 18	163	18.3	13.0	12.7	r	10.7	r	0	0	0	0	0	0	0	0	0	0	0	0		
Apr. 29	205	19.0	7.7	9.7	r	6.0	r	0	0	0	0	0	0	0	0	0	0	0	0		

The Effect of the Length of the Light and
Dark Periods on the Initiation of Heading
of Dactylis glomerata

Preliminary tests were conducted with two clones of orchard grass to determine whether it is the length of the light period or the length of the dark period which initiates the formation of heads. Material from two clones of orchard grass started in four inch pots in the late fall of 1941 and allowed to grow at the normal winter day length (9 to 11 hours) until March 1942 at which time the several treatments were begun.

One series was grown under a 16-hour light period and an 8-hour dark period, a second under a 12-hour light period and a 12-hour dark period, and a third under a 12-hour light period plus two hours of supplementary light in the center of the normal 12-hour dark period. This latter condition was the equivalent of a 12-hour day plus two 5-hour nights separated by a 2-hour light period. Light from Mazda lamps was used at approximately 75 to 100 foot candles intensity for all supplementary lighting.

A second trial was conducted in a dark room in the Laboratory building in which all light was supplied by Mazda lamps at an intensity of 250 to 300 foot candles. The plants were shifted from light to dark at intervals which provided the following light and dark periods: (1) 10 hours light, 14 hours dark; (2) 10 hours light, 8 hours dark; (3) 16 hours light, 8 hours dark, and (4) 16 hours light, 14 hours dark.

The results, after five weeks of the two above trials, may be summarized as follows:

1. In the greenhouse, heads were produced on both clones under two 5-hour nights which were comparable in size to those produced under a 16-hour photoperiod, whereas under a 12-hour photoperiod the clone which requires a 16-hour photoperiod to initiate heading did not head. The other clone which heads poorly under a 12-hour photoperiod produced characteristic prostrate heads.

2. In the laboratory dark room, the plants under a 10-hour day and 14-hour night produced no visible heads, those under a 16-hour day and a 14-hour night produced several heads on the clone normally flowering poorly under a 12-hour day but none on the plant which flowers only with a 16-hour day. Under a 10-hour day and an 8-hour day heading was

similar to that in plants receiving a 16-hour day and an 8-hour night with the exception that plants under the latter light treatment headed several days earlier.

3. The above trials strongly suggest that in orchard grass the duration of the dark period may be more important than the length of the light period in initiating heading.

Effect of Temperature on Germination and Early Seedling Establishment of Pasture Plants

The preliminary experiment conducted in the environmental control chambers on the effect of temperature and day length on the germination and early growth of several pasture species has been completed. The data here presented will include some results previously reported (1941 Annual Report, Pages 33 to 56).

The species used in this experiment included Sudan grass, bromo grass, meadow fescue, timothy, orchard grass, Kentucky bluegrass, colonial bent grass and Ladino clover. Fifty heads of each species were planted in fertile soil in one gallon glazed jars and were placed under the particular environment immediately so that the differences in growth obtained reflect the influence of the controlled conditions for the entire growth period. The various environmental conditions included daily alternating temperatures of 40° to 55° F., 55° to 70° F., and 70° to 85° F., and 85° to 100° F. The lower temperature was maintained for four hours in the center of the dark period, the higher temperature was maintained for four hours in the center of the light period and the temperature changes were effected by gradual increases and decreases, respectively, during the intervening 8-hour periods. The relative humidities were so controlled that the vapor pressure deficit was approximately the same at all temperatures. The soil temperature was the same as the air temperature in each treatment. Superimposed upon the temperature treatments were two day lengths, a 9-hour and a 16-hour photoperiod.

The germination counts of all species were made every other day. At intervals of two, four and six weeks after date when approximately 50 per cent of the total number of germinable seeds had germinated that jar was removed from the chamber, the soil was washed from the plants and measurements were made of the number of leaves, height of leaf, length of roots, origin of adventitious roots, total top growth (dry weight) and total root growth (dry weight). It will be noted from Table 12 that in almost every case except at temperatures of 85 to 100° F. the dry weight of tips and roots was greater

Table 12. Net increase in milligrams per plant during six weeks after germination when grown under various conditions of temperature and day length.

Species	Daily alternation of air and soil temperatures											
	40-55°			55-70°			70-85°			85-100°		
	16 hr.	9 hr.	day	16 hr.	9 hr.	day	16 hr.	9 hr.	day	16 hr.	9 hr.	day
	day	day	day	day	day	day	day	day	day	day	day	day
T o p s												
Orchard grass	8.51	3.24	30.03	7.02	19.26	5.05	0	1.35				
Sudan grass	5.87	6.26	31.22	21.70	122.10	87.05	120.2	56.00				
Ladino clover	4.96	1.87	7.31	2.13	20.84	3.75	0	0				
Meadow fescue	11.96	4.87	31.00	13.39	26.60	8.39	0	1.69				
Brome grass	8.25	6.23	20.96	11.74	28.41	13.69	0	4.74				
Timothy	4.01	1.58	10.49	4.08	6.67	-	0	.66				
Kentucky bluegrass	1.09	.88	8.07	2.03	4.86	1.88	0	0				
Colonial bent	1.41	.81	6.08	1.16	3.98	.79	0	0				
R o o t s												
Orchard grass	3.70	1.18	11.82	2.23	7.60	1.23	0	.24				
Sudan grass	1.43	.76	19.71	9.62	56.10	31.90	44.10	10.75				
Ladino clover	2.98	1.20	2.94	1.10	5.63	.82	0	0				
Meadow fescue	5.71	1.30	9.02	3.56	11.04	1.96	0	.20				
Brome grass	5.57	3.33	15.94	5.78	15.11	4.25	0	.89				
Timothy	2.05	.58	6.28	.93	2.16	-	0	.13				
Kentucky bluegrass	.56	.31	2.99	.64	1.48	.39	0	0				
Colonial bent	.78	.31	2.21	.40	1.16	.22	0	0				

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under the 16-hour photoperiod than under the 9-hour photoperiod. Some increase was expected since the plants received about 78 per cent more radiant energy at the longer photoperiod. The amount of incident energy, however, may not alone account for the entire difference since at the favorable temperatures for growth, the dry weight increases under a 16-hour day were much more than 78 per cent greater than under a 9-hour day. It is possible that a photoperiod stimulus may have been a factor in addition to the increased time for carbohydrate synthesis. The reason for the better growth with the 9-hour photoperiod at 85° to 100° F. was not determined but it may have been caused by the light increasing the temperature of the plant tissues above the controlled air temperature under the 16-hour photoperiod. Where the temperature was already limiting, a slight increase above this temperature resulted in the death of the plants.

The root-top ratios (Table 13) increased with a decrease in temperature except with Sudan grass and in most cases the ratio was higher at long day than at short day. As the growth of the plant increased during the six weeks period the amount of roots compared with the tops also increased. Under a 16-hour photoperiod at two, four and six weeks after germination the root-top ratios of all species were 0.36, 0.43 and 0.45, respectively, and under the 9-hour photoperiod the ratios of all species were 0.23, 0.26 and 0.31, respectively.

The total number of leaves was greatest for each species at the temperature and day length which was most favorable for growth. The number of leaves in most cases was greater under a 16-hour photoperiod than under a 9-hour photoperiod. In the exceptional cases the total number of leaves was the same. Similarly the leaves were considerably longer in all species under the longer day length and under conditions most favorable for growth.

Carotene Determination of Pasture Plants

A number of miscellaneous studies on methods of carotene determination and the carotene content of pasture plants were made.

The procedure ordinarily followed at the Laboratory for the analysis for carotene involves the disintegration of the fresh sample under alcohol in the Waring Blendor, saponification of chlorophyll with alcoholic potash for 30 minutes and extraction of the carotene with petroleum ether. Studies were made to test the claims of Seshan and Sen that saponification with alcoholic potash did not give the maximum yield of carotene

Table 13. Root-top ratios of eight forage species six weeks after germination when grown under various conditions of temperature and day length.

Species	Daily alternation of air and soil temperatures											
	40-55°				55-70°				70-85°			
	16 hr.	9 hr.	16 hr.	9 hr.	16 hr.	9 hr.	16 hr.	9 hr.	16 hr.	9 hr.	16 hr.	9 hr.
	day	day	day	day	day	day	day	day	day	day	day	day
Orchard grass	.43	.36	.28	.32	.39	.24	.39	.24	.39	.24	.39	.18
Sudan grass	.24	.12	.39	.44	.46	.37	.46	.37	.46	.37	.46	.19
Ladino clover	.60	.64	.63	.52	.27	.22	.27	.22	.27	.22	.27	0
Meadow fescue	.48	.27	.40	.27	.42	.23	.42	.23	.42	.23	.42	.12
Brome grass	.68	.53	.76	.49	.53	.31	.53	.31	.53	.31	.53	.19
Timothy	.51	.37	.59	.23	.32	-	.32	-	.32	-	.32	.20
Kentucky bluegrass	.51	.35	.37	.32	.30	.21	.30	.21	.30	.21	.30	0
Colonial bent	.55	.38	.36	.40	.29	.28	.29	.28	.29	.28	.29	0
Average	.50	.38	.47	.37	.37	.27	.37	.27	.37	.27	.37	.18

and that saponification with caustic potash should precede that with alcoholic potash. Some data, given in Table 14, indicate that, contrary to Seshan and Sen, treatment with caustic potash gives lower results and that heating with alcoholic potash for 30 minutes is, in the absence of an absolute method, quite satisfactory.

Table 14. A comparison of the effects on the yield of carotene of three methods of saponification during the determination of carotene. Results as mgs. of carotene per kilo of dry matter.

Type of sample	Method of saponification		
	Alcoholic KOH: for 30 min.	Alcoholic KOH: for 60 min.	KOH followed by alcoholic KOH
Mixed grass	438	402	364
White clover	452	457	236

Since carotene must be determined on fresh materials, the number of carotene analyses that may be completed in one day is limited by the number of workers available and the equipment at hand. Any method of shortening the procedure or of preserving the samples with carotene intact would increase the number of plants that could be sampled at a given time. The possibility of drying forage and storing without loss of carotene was investigated. Five gram samples of orchard grass were dried in a Dietert forced air dryer and stored at room temperature. Some samples were also carried through the saponification step and then stored in the refrigerator. The results are given in Table 15. Losses in carotene were not observed during rapid air drying but losses occurred during storage in samples not dried sufficiently to remove most of the moisture. Separate tests with 20 g. samples indicated that a final drying temperature of 73 degrees after five minutes removed only 78 per cent of the original moisture and one of 95 degrees removed 95 per cent of the moisture. Another useful observation was that the grass carried to the saponification stage could be stored in the refrigerator five days without significant loss of carotene. The latter observation has been put into practice and has been made possible the handling of a larger number of samples for analysis on the same day.

Table 15. The effect of drying and storing orchard grass for carotene analysis on the carotene content found. Results as mgs. of carotene per kilo of fresh weight.

Method of drying	Temperature reached	Analyzed without drying	Dried and analyzed immediately	Dried and stored five days before analyzing
No drying	-	93.8	-	-
No drying, but stored after saponification	-	93.3	-	-
High heat, 1 min.	92	-	90.1	93.2
High heat, 3 min.	99	-	94.8	96.9
Low heat, 1 min.	65	-	95.8	89.0
Low heat, 3 min.	68	-	93.1	88.2

It has also been noted that, if the sample is ground in the Waring Blendor after the saponification instead of before, the disintegration of the material is more complete and the sample may then be transferred to a separatory funnel for extraction with ether rather than by the more laborious method of extraction by decantation. The fibrous material is usually disintegrated so completely that clogging of the funnel rarely results.

It is generally believed that plants of a darker green color are higher in chlorophyll and in carotene than lighter plants. The selection of plants of higher carotene content on the basis of color would be advantageous. Fifty clones of orchard grass in three replications were compared under fluorescent light with eight selected shades of green from Ridgeway's Color Chart and graded on a scale of one to eight with increasing darkness of green color. The reading of the different replications by two observers was fairly uniform but the classification did not fit in all cases that given in daylight in the field. Six clones were selected in the

field and carotene analyses were made. The results are given in Table 16. The three "dark" clones averaged higher than the three "light" clones in carotene. The second replication was, on the average, the lowest in carotene and the third the highest. The average classification of 42 clones of which all three replications were present is also given in Table 16. It perhaps is significant that replication 2, which had the lowest carotene content for the six clones, had the lowest average color value while replication was highest both in color and in average carotene.

Table 16. The color classification and the carotene content of orchard grass.

Clone	Color Classification			Carotene			
	In	By chart					
	field	(3 rep.)		Rep.1	Rep.2	Rep. 3	Ave.
11(11)	light	3-3-5		258	246	295	266
2(14)	light	5-1-3		274	289	300	288
14(12)	light	6-5-4		301	267	321	296
18(3)	dark	2-3-7		237	313	424	325
13(2)	dark	7-7-8		400	240	369	336
12(6)	dark	6-5-4		413	384	443	410
Ave. of 6 clones				314	290	357	-
Ave. color classification of 42 clones by chart				5.45	4.74	5.60	-

Variation in Chemical Composition of *Trifolium repens* with various degrees of rust resistance

In previous studies of rusted and rust-free white clover plants it was noted that the few resistant plants studied were higher in carotene than the rust-susceptible plants (1940 Annual Report, Page 41). Further studies were carried out on clover plants of varying degrees of rust resistance.

The plant material consisted of two groups of 20 plants each. Each group was the progeny of a cross, one-half of each group being derived from the reciprocal cross of the other half; the two groups had one parent in common. The plants were grown in the greenhouse in the winter of 1941-42 and transplanted to the field in the spring. They were sampled for carotene once while

in the greenhouse and again while in the field. They were also sampled while in the field for determination of sugars, invertase activity and oxidase activity on the expressed sap. At the time samples for analyses were collected no rust was present.

The results of the analyses are reported in Tables 17 and 18. No relation to the previously observed rust resistance was found in any of the constituents studied. However, while it was noted that there was considerable variation from plant to plant in all the constituents studied, differences between crosses were not significant nor was there any significant correlations among any of the constituents.

Table 17. Maximum, minimum and mean values of carotene content of white clover.

	:: Greenhouse, May 4		:: Field, June 24	
	:: Cross : Cross		:: Cross : Cross	
	:: I x V : II x V		:: I x V : II x V	
No. of plants	:: 20	: 14	:: 20	: 20
Maximum, p.p.m.	:: 596	: 612	:: 557	: 550
Minimum, p.p.m.	:: 424	: 442	:: 378	: 365
Mean, p.p.m.	:: 509	: 512	:: 458	: 458
	::	:	::	:

Table 18. Maximum, minimum and mean values of sugars (as mgs.), of oxidase activity (as ml. of 0.01N $\text{Na}_2\text{S}_2\text{O}_3$) and of invertase activity (as mgs. of sucrose) in white clover.

	:: Sugar		:: Oxidase Activity		:: Invertase Activity	
	:: Cross : Cross		:: Cross : Cross		:: Cross : Cross	
	:: I x V : II x V		:: I x V : II x V		:: I x V : II x V	
No. of plants	:: 17	: 13	:: 19	: 16	:: 17	: 17
Maximum*	:: 169.9	: 170.7	:: 10.7	: 13.3	:: 107.8	: 125.6
Minimum*	:: 97.3	: 82.2	:: 3.1	: 4.1	:: 24.3	: 12.6
Mean*	:: 128.2	: 115.2	:: 6.0	: 7.1	:: 55.4	: 59.6
	::	:	::	:	::	:

* per ml. of plant juice.

A manuscript summarizing the results of this study has been submitted for publication (Page 65).

Carbohydrate Metabolism of Grasses

Soluble carbohydrate changes in roots and stubble of perennial ryegrass after defoliation have already been described (1941 Annual Report, Page 41). Alcohol insoluble carbohydrates and nitrogenous compounds have also been studied.

Reducing substances liberated by normal sulfuric acid at 100° C. for 2.5 hours were found, after correcting for fructose, to be mainly non-fermentable sugars. They are assumed to be pentoses, since qualitative tests for galactose were negative. Calculated as xylose the amounts found in roots agree closely with results obtained by the furfural distillation method.

The amounts of pentoses increased from 23.9 per cent of the roots and 16.2 per cent of the stubble at the time of defoliation to maxima of 25.3 per cent of the roots and 20.3 per cent of the stubble eleven days after defoliation. Cellulose also increased from 32.0 per cent of the roots and 27.4 per cent of the stubble at the time of defoliation to maxima of 34.3 per cent of the roots at eleven days and of 33.0 per cent of the stubble at 16 days after defoliation. Pentoses and cellulose did not further increase but dropped slightly after attaining the maxima on the basis of percentage of dry weight. Lignin increased from 12.2 per cent of the roots and 4.0 per cent of the stubble at the time of defoliation to reach 15.0 per cent of the roots and 5.1 per cent of the stubble at the end of the 36-day period of the experiment.

The increases in these insoluble constituents on a percentage basis may indicate an actual production of these substances in old or in newly formed tissues but may also be the result of the method of expression as percentage of the dry weight. Soluble carbohydrates were being depleted rapidly for the first eleven days after defoliation and any other constituents, even if not actually increasing, might show an apparent increase on a percentage basis. Percentages of cellulose and pentoses dropped slightly when soluble carbohydrates were being restored during the latter part of the 36-day period. Lignin however did not show this later decrease. It may be concluded that cellulose, pentoses, and lignin were not utilized in the manner of the soluble carbohydrates and should not be classed as reserve substances.

In plants placed in darkness after defoliation, pentoses, cellulose, and lignin showed continued increase throughout the course of the study.

The amount of total nitrogen of defoliated plants showed slight changes. In the stubble it increased from 1.2 per cent at the time of defoliation to a maximum of 1.5 per cent after seven days and then decreased to 1.1 per cent. The roots contained 1.0 per cent and showed little change. The proportion of the total nitrogen soluble in alcohol showed greater fluctuations. It increased from 16.8 per cent in the stubble and 8.2 per cent in the roots to maxima of 22.0 per cent in the stubble after seven days and of 13.5 per cent in the roots after four days. In darkness it increased to 24.1 per cent in the roots and 48.7 per cent in the stubble just before the end of the 36 day period and then dropped rapidly. It is concluded that although changes in total nitrogen were not great there was a tendency for protein to be hydrolyzed into more soluble constituents after defoliation. The solubilization was more active in plants kept in darkness.

A manuscript summarizing the results of this investigation has been prepared (Page 65).

Composition of Diploid and Tetraploid Lolium perenne with Respect to Certain Chemical Constituents

Further studies were made of the comparative composition of diploid and tetraploid plants of perennial ryegrass (1940 Annual Report, Pages 33 to 35). There were no significant differences in total, soluble or insoluble nitrogen between diploid and tetraploid plants from four clones of ryegrass grown under two levels of nitrogen nutrition and under three clipping treatments in the greenhouse nor from six clones grown in field rows. There were also no significant differences in the fructosan content of the diploid and tetraploid plants of the six clones in the field. In the four clones grown in the greenhouse fructosans were not present except in plants grown under low nitrogen fertility and under the less severe clipping treatments. In these cases fructosans were usually higher in the diploid plants but not significantly so.

Clonal Variations in the Mineral Content of Trifolium repens

Last year (1941 Annual Report, Pages 44 to 47) it was shown that under certain environmental conditions some clones of white clover tended to be relatively high in percentage calcium whereas other clones tended to be relatively low.

Similar results were obtained for the phosphorus content of different clones. These results were summarized and published (Page 65).

This year in an attempt to obtain material of comparable physiological age samples consisting of the youngest fully developed leaf were analyzed. Samples were taken at different times during the year both in the field and in the greenhouse. In samples harvested at the same date the young leaves were higher in percentage phosphorus and lower in calcium than older leaves from the same clone. Young leaves from the same clone varied widely in percentage calcium and phosphorus from one sampling date to another. Moreover in some cases clones that were relatively high in calcium or phosphorus at one sampling date were low in those elements at other sampling dates.

Soil Moisture in Relation to Pasture Management

Studies are in progress to determine the effect of two levels of nitrogen fertilization and two clipping treatments on soil moisture content under a Kentucky bluegrass-white clover sod. Gypsum blocks have been placed in the various plots at depths of 4, 10, and 20 inches and resistance readings will be taken at frequent intervals during the next growing season. The soil moisture determination thus obtained will be correlated with the fertilization and management treatments.

Clonal Variation in the response of Poa pratensis to nitrogen fertilization and management

Previous results in the field (1941 Annual Report, Pages 43 and 44) as well as in the greenhouse showed marked differences in the ratio of tops, roots, and rhizomes of different clones of Kentucky bluegrass. Twenty-one of these clones were selected to determine the differences in total production of dry matter and in the ratio of tops, roots, and rhizomes at three levels of nitrogen fertilization, two day lengths, and two clipping treatments in the greenhouse. The clones were increased by vegetative propagation and then transplanted to 1-gallon pots of soil. Total dry weight of clippings are being determined and at intervals of eight to 10 weeks one series is washed free of soil and the weight of both roots and rhizomes determined. The experiment is still in progress.

The Effect of High Soil Temperatures on Subsequent Plant Growth

Earlier trials (1941 Annual Report, Page 43) showed that on certain soils very poor growth of Ladino clover was obtained following incubation at 40 to 45° C. Moreover, the injurious effect of incubation could be overcome by applying a liberal amount of phosphate. A report of these results has been published (Page 65). Studies were continued to determine the effect of incubation in relation to:

1. Soil type.
2. Soil acidity.
3. Amount of phosphate added.
4. Test crop employed.
5. Length of incubation period.
6. Temperature of incubation.
7. Soil moisture content.
8. Reinoculation of the soil.
9. Availability of minor elements.

Trials with three soils, two subsoils, and a mixture of kaolin and sand all showed that poor growth was obtained following incubation at about 45° C. The injury occurred on both limed and unlimed soils.

In all cases the ill effects of incubation could be overcome by adding large amounts of phosphate. The minimum amount of phosphate required to overcome the ill effect of incubation varied with the soil and with the crop. On one soil between 800 and 1200 pounds of P_2O_5 per acre on incubated soil was required to produce as good growth of Ladino clover as was obtained from 150 pounds of P_2O_5 on the unincubated soil. The phosphate was effective in overcoming injury whether applied before or after incubation.

The length of the incubation period was less important than the temperature of incubation. In one trial samples of soil incubated one week at 40° C. produced as good a growth as soil that received no incubation. On the other hand incubation for a few hours at 50° C. produced a marked reduction in yield of clover. In steam sterilized soil the growth response was very similar to that in incubated soil.

At relatively low incubation temperatures (50° C.) soils incubated wet produced much poorer growth than when incubated dry. At higher temperatures and in steam sterilized soil the moisture content appeared to be unimportant.

In Ladino clover the poor growth following incubation could not be overcome by applications of boron, copper, manganese, zinc, calcium silicate or by inoculating with Rhizobia or with a suspension of untreated soil.

From the results of these experiments it appears that liberal applications of phosphate can be used effectively to overcome the poor plant growth that sometimes follows partial sterilization of the soil.

PATHOLOGY

Sclerotium rhizodes on Grasses in Pennsylvania

Sclerotium rhizodes was observed during the spring of 1942 parasitizing leaves of Poa pratensis and Agrostis alba in a lightly grazed pasture near Alexandria, Pennsylvania. Since this represented the first known occurrence of the disease in Pennsylvania, periodic trips were made to the infected pasture to observe the progress of the disease.

Three weeks after the disease was first observed, nearly all infected leaves of Poa pratensis were overgrown by healthy leaves of the same or neighboring plants. At that time severe infection was noted on Agrostis alba so that numerous plants were stunted and shriveled from effects of the disease.

A number of diseased plants of Agrostis alba were removed from the field and placed in pots in a greenhouse. New diseased leaves grew from infected culms but the mycelium failed to spread to adjacent healthy plants.

Sclerotia from diseased leaves were plated on potato-dextrose agar. Slow but vigorous growth soon gave rise to a mat of dense, fluffy white mycelium liberally dotted with sclerotia similar to those found on diseased plants.

The organism was not found in numerous other pastures that were examined. This outbreak represented either an isolated attack or else the disease was overlooked in other areas favorable for its development. A note on the occurrence of the disease was published during the past year (Page 65).

Studies in Ustilago striaeformis

Continuing the smut surveys and investigations reported last year (1941 Annual Report, Page 49), observations were made and smutted plants were collected from more than 75 pastures in Pennsylvania. A race of Ustilago striaeformis on Agrostis alba was found to yield fresh, germinable chlamydospores. Investigations conducted on this race of smut showed that chlamydospores selected from the same sorus or from different sori on the same plant varied in ability to germinate. Single chlamydospore cultures of this race of the organism were grown on artificial media. The cultures were strictly mycelial in growth-form and could be differentiated into two biotypes. A manuscript on this phase of the work was presented for publication (Page 65).

Since most fresh chlamydospores of Ustilago striaeformis fail to germinate unless they are after-ripened for more than 200 days, experiments were conducted to find a method for inducing germination of fresh spores. In a study of the influence of temperature on growth and development of diseased plants of Poa pratensis, it was found that fresh chlamydospores from smutted leaves of plants grown at 32° C. showed as high as 90 per cent germination. Spores from plants grown at lower temperatures failed to germinate.

That races of the organism with germinable fresh spores are probably rarely encountered was indicated by the fact that chlamydospores from more than 300 smutted plants failed to germinate when they were tested in distilled water.

Diseased plants from different clones were grown at temperatures of 1.5°, 10°, 20° to 25° and 32° C. Plants maintained at the lower temperatures retained their smut infections and continually produced new infected, green leaves. Plants growing at 20 to 25° C. also retained smut symptoms but the severity of the disease caused the leaves to turn yellow and wither prematurely. Of 23 smutted clones maintained at 32° C. only 14 were alive after four months. Most of the leaves that were present when the plants were placed at this temperature died shortly thereafter. New leaves that emerged were long and very narrow so that the smut spores developed within small, separated sori scattered the length of a leaf. New shoots that developed from diseased plants often produced leaves that showed no visible symptoms of smut infection. When these plants were placed at a lower temperature and were left for a time, many of the plants regained their smut symptoms. A few, however, remained free of symptoms for more than three months. The results of this study have been summarized and presented for publication (Page 65).

It was found also that treatment of detached smutted leaves at 35° C. for 10 to 30 days was effective in inducing the chlamydo-spores to germinate.

The prevalence of smut on Kentucky bluegrass in pastures in Central Pennsylvania was studied by sampling 13 representative pastures. Each pasture was divided by estimation into four sections and fifty sod plugs, one and one-half inches in diameter, were removed at random from each section. Each sod plug was examined for smut as soon as possible following collection and the number of plugs containing smutted plants was recorded. Previous experience had shown that some plants which were free of disease symptoms at the time of collection developed smut when grown under favorable conditions in a greenhouse. The sod plugs collected from each pasture therefore were placed in flats containing wet peat moss and the plants in the plugs were examined periodically for smut.

Immediately after collection the percentage of plugs containing smutted plants varied from 0.5 to 11.5 per cent for the thirteen pastures. After the plants had grown for two months in a greenhouse, the numbers of plugs with smutted plants had in most cases doubled or multiplied many fold, the percentages at that time ranging from five to 25 per cent for the different pastures. The results of this investigation indicate that far more smut may be present in pastures than is generally realized.

Seed Treatment for Control of Damping-off of Forage Grasses and Legumes

Investigations begun last year on this problem were intensified in view of impending shortages of certain forage grass and legume seed stocks. Results of nursery tests conducted at different times during the growing season indicate that seed treatment of some grasses and legumes may be beneficial under a wide range of conditions at time of planting. This suggests the possibility that rate of seeding may be reduced by seed treatment, particularly where seed stocks are inadequate.

Preliminary experiments established in the field at seven different dates during the spring and fall of 1942 showed that Sudan grass averaged a 12 per cent increase in stand for treated seed. In one test, an increase in stand of twenty-four per cent resulted when treated seed was used. The dusts Sporgon and Semesan gave best results while DuBay 1205FF and Yellow Cuprocide were slightly less beneficial.

Field tests conducted on alfalfa revealed that stands were increased five to 17 per cent when the seeds were dusted with Yellow Cuprocide. The average increase in stand for five field tests was eight per cent. Although Yellow Cuprocide gave the greatest average increase in stand, seeds treated with Spergon or LuBay 1205FF were similarly benefited.

When seeds of red clover were treated with LuBay 1205FF, an average increase of nine per cent resulted under field conditions. The greatest increase in stand for any one planting was 12 per cent.

Tests conducted with orchard grass and Kentucky bluegrass showed no increase in stand when treated seeds were planted.

Results of greenhouse tests using steamed soil and known pathogenic cultures of species of Pythium showed that most seed treating agents were highly beneficial. The effectiveness with which damping-off may be controlled by some seed treating dusts is shown in Figure 2. The dusts that were most satisfactory under field conditions often were not outstanding in greenhouse tests. In order to help clarify this situation, experiments were conducted in the greenhouse to determine the relation of soil moisture, fertilizer treatments, temperature, and other factors to the effectiveness of seed treatments in controlling damping-off. Results, although incomplete, indicate that each of these factors probably plays a significant role in determining the efficiency of seed treatment. A note summarizing these results was submitted for publication (Page 65).

SUMMARY

COOPERATIVE ACTIVITY

The pasture collaborators in the Northeastern United States did not hold the usual annual meeting during 1942, hence, some of the matters normally taken care of at such meetings were handled by correspondence and individual conferences. Some progress was made in the study of plant-weather relations suggested at the annual meeting in 1941 but substantial development of this study will likely be postponed until after the War. Three additional memoranda of agreements between state stations and the Laboratory have been proposed as bases for cooperative research. With the completion of these agreements formal cooperative relations will have been established between ten state stations and the Laboratory.

COOPERATIVE PROJECTS

With the objective of obtaining facts that would be helpful in planning pasture renovation in the northeastern states, cooperative experiments have been started in Connecticut, Maine, Massachusetts, Pennsylvania, Rhode Island and Vermont. The experiments involve such renovation procedures as seed bed preparation, fertilizer placement and choice of plant species including both grasses and legumes.

Work has progressed satisfactorily on the projects to develop improved strains of pasture plants by breeding. Limited quantities of seed of new strains of orchard grass and of Kentucky bluegrass are available for further testing.

Other cooperative projects involve over-liming injury, investigations of snow mold, anatomy of grass seedlings as influenced by environmental factors, and chemical composition of pasture grasses. Summaries of progress on these projects as well as more complete summaries of progress on the projects mentioned above may be found in the section (Page 2) designated for this purpose.

RESEARCH PRIMARILY AT THE LABORATORY.

Cytogenetics and Breeding of Grasses

In continuation of investigations of ability to set seed under bag in orchard grass, self- and open-pollinated panicles were collected from more than 6,000 plants during the summer of 1942. Determination of number of seeds per panicle is now nearly completed. For studies of the inheritance of male sterility, plants of 133 F_2 and 34 backcross progenies, totaling over 7,000 plants, were spaced in the field in the fall of 1942.

In Kentucky bluegrass, 33 new strains were seeded in plots 2' x 3' and 77 new strains were seeded in plots 3' x 5'. Only observational data will be collected from these plots and the behavior of the selected strains will be correlated with their behavior when tested subsequently in larger plots.

Thirteen selected strains and two commercial seed lots of Kentucky bluegrass were tested using two clipping treatments, viz. (1) until July 1, plots clipped to 1/2 inch when plants averaged three to four inches in height; after July 1, plots clipped to one inch when plants averaged four to five inches, (2) plots clipped throughout the summer to one inch when plants averaged four to five inches. The percentage of white clover was not affected differentially by the clipping treatments at any time during the growing season. The close clipped plots yielded

25 per cent more than those clipped to one inch for the season total but actually produced less during July, August and early September. The strain X clipping treatment interaction was not significant at any clipping date. Significant differences among strains were found in yield and in percentage of associated white clover. Some of the selected strains yielded considerably more than the commercial checks particularly during midsummer. A method for determining the botanical composition of the herbage from the plots was devised and tested.

Data were obtained from second generation progeny tests of method of reproduction in Kentucky bluegrass. The results agreed in general with those from first generation tests but indicated that there was considerable error in classification based on the latter tests.

A replicated polycrossing plot planted with 257 clones of orchard grass has been established to provide material for testing the usefulness of this method for evaluating the breeding potentialities of individual plants.

Plants from 347 I_3 lines of orchard grass have been established in the field, planted in rows adjacent to their parental, I_1 , and I_2 clones. Also, an additional 173 I_1 progenies were planted.

In sudan grass, 447 progenies, each from three to seven generations inbred, were grown and selfed seed was obtained from plants of 177 progenies selected as superior in disease resistance and agronomic characters. In yield trials of 69 selected inbred progenies, significant differences were obtained among progenies. All were inferior in yield to Tift, an open-pollinated strain. Using red pigmentation as a dominant marker, percentages of natural crossing of 61, 77 and 76 per cent were obtained in three trials.

Tests are now in progress to determine the allelism of phenotypically similar young plant characters that have been obtained from unrelated inbred progenies of orchard grass. In field studies, resistance to Stagonospora leaf spot in orchard grass behaved as a dominant character. In greenhouse studies of inbred progenies of orchard grass resistance to mildew was dominant to susceptibility and apparently conditioned by a single factor.

Investigations of meiosis in timothy are being continued particularly in the analysis of the inter-relationships of the various features of meiosis. Studies of F_2 and backcross plants of diploid perennial ryegrass substantiated the hypothesis of a single major factor plus modifiers conditioning partial asynapsis in meiosis.

Studies of meiosis in triploid perennial ryegrass were continued. Among 130 open-pollinated progeny plants of the triploid, there was an excess of diploid ($2x$) and $2x + 1$ plants and a deficiency of those with two or more extra chromosomes compared with expectation based on chromosomal distribution at anaphase I. Additional data were collected on meiotic behavior in autotetraploid perennial ryegrass.

The data on meiotic behavior collected from nine replicated clones of orchard grass were analyzed by the analysis of covariance and the results have been summarized and interpreted. Studies of meiotic behavior of 83 I_1 plants from eight families showed an average incidence of unpaired chromosomes at metaphase I in the inbreds that was two to three times greater than that of their parents. Within inbred progenies, percentage of metaphase I sporocytes with univalents, percentage of anaphase I with laggards, and percentage of quartets with micronuclei were significantly and negatively correlated with both self- and open-pollinated seed set. The increased frequency of metaphase I univalents that accompanied inbreeding could be attributed in part, but not entirely, to a decrease in chiasma frequency.

Cytogenetics and Breeding of Legumes

In white clover, those studies of the self-fertility allele (S_F) which relate to its use in a practical breeding program, have been continued by making appropriate test crosses in the greenhouse and by self-pollinating and resultant progenies under bag in the field. Likewise, the study of the number of oppositional alleles causing cross-incompatibility is being continued using plants collected from two locally-confined natural populations.

When eight clones of white clover which differed significantly in degree of pseudo-self-compatibility and which were recessive for two marker characters were crossed under the bee cages during two years with other clones homozygous for these markers, the per cent crossing ranged from 85 to 100 for different cages and was significantly different for the eight clones. In the case of a self-compatible plant, the per cent crossing was only 19.

Naphthalene acetic acid applied in several ways and in concentrations from one to 100,000 p.p.m. did not induce self seed to set in either self-incompatible or pseudo-self-compatible plants of white clover.

Second and third generation inbreds of white clover were much reduced in vigor in comparison with their parental clones. New inbred lines will be started using F_1 progenies resulting from crosses with a clone homozygous for S_f .

Among the plots started in 1941 from 100 selected white clover plants, highly significant differences in per cent clover were noted. In the plots established from F_1 seedlings obtained by crossing good, medium and poor yielders, significant differences were noted in per cent clover throughout the season as well as for the type of parent. Selections have been made from the 1940 Ladino collections, and additional seed and clones were collected in 1942 from widely scattered areas in the Northeastern Region.

No linkage was observed between the oppositional alleles causing cross-incompatibility and four leaf marking genes. In the F_2 and backcross progenies from plants differing in amount of HCN, two simple Mendelian factors were identified, one conditioning the presence or absence of glucoside and the other of enzyme. Most of the evidence indicated no linkage between these factors, nor between them and the factor conditioning v-shaped white areas on the leaf blade.

In the open-pollinated progenies of red, alsike and sweet clover the total per cent of aneuploid plus polyploid plants was 51, 41 and 58, respectively, the remaining individuals being normal diploids.

The 64-chromosome cuttings of white clover, induced by colchicine treatment, were just as self-incompatible as the 32-chromosome cuttings from which they arose. The 64 x 32 and 32 x 64 crosses averaged only 0.3 and 0.5 seeds per head.

Physiology and Composition of Pasture Plants

Additional information has been obtained on the factors affecting heading of orchard grass and Kentucky bluegrass. Grown continuously under a 16-hour photoperiod neither species headed during six months in the greenhouse, but when the plants were preconditioned by being grown under the short days and lower temperatures of fall and winter in the field for periods of two to three months, they produced heads after removal to a 16-hour photoperiod in the greenhouse. Floral primordia of Kentucky bluegrass were initiated in the field during December and January.

From other heading studies of orchard grass there was evidence that the length of the light period in the initiation of heading was effective primarily because it reduced the duration of the dark period. Supplementary light for two hours in the middle of the normal dark period was as effective as a 16-hour day in initiating heading of this species.

Studies on the germination and seedling establishment of seven grasses and one legume under controlled environments indicated a wide variation in species response. All species except sudan grass were seriously injured or killed at temperatures of 85° to 100° F. Sudan grass was seriously injured at low temperatures of 40° to 55° F. whereas the other species grew slowly but were not injured. Total growth was greater under a 16-hour day than a 9-hour day and root top ratios in general increased with an increase in day length and with a decrease in temperature.

Studies were made of the method of carotene determination. Drying and storing of the plants did not reduce the subsequent recovery of carotene if the drying was sufficient to remove most of the moisture. Storing the samples in the refrigerator after saponification with alcoholic potash likewise did not cause a loss in carotene. Saponification with caustic potash previous to the saponification with alcoholic potash did cause a loss in the carotene yield. A more efficient grinding of the sample was obtained after saponification rather than before.

In orchard grass dark colored clones were higher in carotene than lighter clones.

In white clover considerable variation was found in carotene, oxidase and invertase activities and in total sugars. There was no relation between any of these constituents and rust resistance.

After partial defoliation of perennial ryegrass, there were no indications that cellulose, lignin or acid-hydrolyzable pentosans were available as reserve substances to support the growth of new tissue. Proteins were hydrolyzed, especially in plants in darkness.

A comparison of diploid and tetraploid ryegrass plants indicated no particular differences in fructosan or protein.

In white clover the relative calcium content of different clones of the same physiological age varied with changes in environmental conditions. Similar results were obtained for the phosphorus content of these clones.

Studies were initiated with Kentucky bluegrass to determine clonal differences in total production of dry matter, and in the ratio of tops, roots, and rhizomes in relation to nitrogen fertilization, day length, and clipping treatments in the greenhouse. Field studies were started to determine the effect of nitrogen fertilization and clipping treatment on soil moisture in a pasture.

Studies of the effect of high soil temperatures on subsequent plant growth indicate that the injury which sometimes follows partial sterilization of the soil may be overcome by applying large amounts of phosphate. The phosphate may be applied either before or after sterilization, although it appears that slightly more phosphate may be required if the application is made prior to sterilization.

Pathology

Sclerotium rhizodes was observed parasitizing leaves of Poa pratensis and Agrostis alba in Pennsylvania.

A race of Ustilago striaeformis on Agrostis alba was found to yield fresh, germinable chlamydospores. Single chlamydospore cultures were secured and the cultures were differentiated into two biotypes. The after-ripening period of fresh chlamydospores was reduced appreciably by growing smutted plants of Poa pratensis at 32° C. Treatment of detached smutted leaves at 35° C. for 10 to 30 days was effective in inducing fresh chlamydospores to germinate. Periodic examination of sod plugs collected from representative pastures revealed that far more smut may be present in pastures than is generally realized.

Field and greenhouse tests indicated that better stands of sudan grass, red clover and alfalfa were obtained by treating the seeds with fungicides for control of damping off. On the other hand stands of orchard grass and Kentucky bluegrass were not improved by seed treatment.

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Sullivan, J. T., and Sprague, V. G. Carbohydrate changes in roots and stubble of ryegrass following partial defoliation. Prepared for presentation at meetings of the American Society of Plant Physiologists.

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Atwood, S. S. Natural crossing of white clover by bees.

Atwood, S. S., and Sullivan, J. T. Inheritance of a cyanogenetic glucoside and its hydrolyzing enzyme in white clover.

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Sullivan, J. T. The differential action of permanganate and ceric sulfate on cuprous oxide prepared in the presence of iodide.

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Wernham, C. C., and Chilton, St. John P. Snowmold of pasture grasses.

Appendix

(The responsibility for compiling each state report was assumed by the collaborator of that state)

PROGRESS REPORT OF STATE STATIONS

CONNECTICUT (STORRS) AGRICULTURAL EXPERIMENT STATION

Title: Alfalfa Experiments

Leaders: B. A. Brown and R. I. Munsell.

a. Response to Soil Treatments. No new developments.

b. Effects of Time and Frequency of Cutting Alfalfa under Different Treatments. Discontinued.

c. Effects of Amount and Depth of Applying Limestone. Alfalfa, reseeded for the third time in 1941 on plots which received limestone at 6,000 pounds in 1933 and none since, yielded slightly more in 1942 than other plots with limestone at 2,000 pounds in 1933 and repeated in 1941. These and previous results indicate that, although quite satisfactory stands and yields of alfalfa may be obtained by fractional liming at each seeding, the only final advantage is a distribution of the costs over a longer period.

d. The Role of Minor Elements in Fertilizing Alfalfa. Symptoms of boron deficiency of alfalfa were not much in evidence in 1942 excepting on fields with very sandy soils. On these sandy soils, 75 per cent of the plants showed boron deficiency at both cuttings. The alfalfa appeared normal but yields were little affected when borax was applied at 20 pounds per acre in the spring of 1940.

Borax at 20 pounds, applied on the surface in April 1940, had increased the available boron to the seventh inch by November 1941.

No benefits were obtained from Mn, Cu or Zn.

Title: The Maintenance and Improvement of Pastures.

Leaders: B. A. Brown and R. I. Munsell.

a. The Effects of Fertilizer Treatments on the Soil, the Flora, and the Production as Measured by Grazing. In 1942, nitrogenous fertilizers were discontinued on five of the seven grazed plots

which had received such treatments for ten years (1932-1941). In preparation for future changes in treatments, the past season was a "transition" period. The data for 1932-1941 are being prepared for publication.

c. The Effects of Various Chemicals on the Soil, on the Botanical Composition of the Sward, and on the Stands and Growth of Kentucky Blue and Rhode Island Bent Grasses. On lawnmown Kentucky bluegrass and Rhode Island bent grass plots, fertilized since 1936 with NaNO_3 at 500 pounds per year, sorrel is now occupying more area than on plots receiving any one of several other N carriers. As the acidity of the soil has been decreased by over one pH unit by the NaNO_3 , it is evident that the sorrel does not flourish because of acid conditions but because it requires less Ca than either of these grasses.

On the same series of plots, applying urea and carbonate of potash in about the N:K proportions found in urine has favored the spread of white clover and since 1939 has produced the largest yields of both grasses.

d. The Adaptability of Varieties and Species of Grasses and Clovers for Pastures. On plots lawnmowed eight times per season, the six-year average increase in yields of dry matter was seven per cent from seeding Kent white clover in four grasses, 37 per cent from seeding Ladino.

After June 15, Ladino-grass mixtures yielded 12 per cent more dry matter than the grasses alone receiving N at 28 pounds in each of the months of April, June and August. For the entire season, the grasses plus N were only three per cent above the Ladino mixtures.

After seven years of lawnmowing 4" to 1", Ladino clover composed 41 per cent of the stand on limed, and 22 per cent on unlimed grass plots. The corresponding values for Kent clover were 11 and six per cent.

There has been a distinct tendency for timothy or orchard grass to be more prevalent when Ladino-grass mixtures were cut four rather than two inches above the ground. Kentucky bluegrass has volunteered more under frequent, close cuttings and this is much more evident in the timothy-than orchard grass-Ladino mixtures. Timothy has been favored by postponing the first cutting until June 15.

Ladino occupied 50 per cent or more of the area after four years of from 6-2 to 10-4 inch cuttings of timothy or orchard grass mixtures. These facts and the lawnmowing experiments,

previously mentioned, indicate that widely variable managerial systems may be practiced on Ladino-grass seedings provided mineral fertilization is liberal.

On the basis of three years' data, yields of dry matter have been reduced by cutting four rather than two inches above the ground. Omitting cuttings after September 1 has given the lowest yields and a larger per cent in the spring months. In general, the largest crops have been obtained from the systems where the first cutting is deferred to the early hay stage, viz., June 1 for orchard grass and June 15 for timothy seedings. However, the quality of these early hay stage cuts has been appreciably poorer and the largest yields of protein in 1941 were obtained from the more frequent cutting systems.

In 1941, from 92 to 154 pounds per acre of K_2O were removed in the grass-clover crops. By far the highest percentages of K_2O occurred in the first cuttings or soon after the annual application of 60 per cent KCl at 250 pounds. Under the same conditions, P_2O_5 removal varied from 30 to 48 pounds or approximately one-third the amounts of K_2O .

Of fifty strains of grasses under test in pure culture, plus high N fertilization and cut three times per season, the Brage strain of orchard grass led all others in summer and fall production. A strain of tall fescue, F. C. 30864, had highest yields in the third cutting (October), but appeared very coarse and unpalatable.

Timothies have been uniformly poor in summer and fall growth, even when the first cutting was made about June 1.

f. Causes of Fluctuations in the Prevalence of White Clover.

As mentioned in previous reports, different types of white clover do not respond in the same manner to variations in cutting treatments. The Kent (very low growing) type is especially sensitive to competition (shade?) of grasses. For example: A part of a liberally fertilized (Ca Mg P K) grass-clover plot was not lawnmowed after July 21, 1941, and consequently the grass was five to six inches high in the fall. On May 28, 1942, that unmowed Kent section had only one per cent clover, while on the remainder, mowed fortnightly in 1941, the Kent clover occupied 90 per cent of the area. The same treatment of an adjacent Ladino-grass plot did not affect appreciably the stand of clover.

Liberal mineral fertilization (Ca P K) has been very effective in maintaining white clover. On tilled fields, with crop removed, it has been particularly important to supply sufficient potash. Added to Ca P K, B, Mn, Cu and Zn, alone or in combination, have not been beneficial and in some cases have been injurious.

During the summer months of 1941, soil temperatures just below the surface were appreciably lower during the hottest part of the day and somewhat higher during the night under Ladino than under Kent clover.

DELAWARE AGRICULTURAL EXPERIMENT STATION

Title: Pasture Management and Milk Production.

Leaders: C. E. Phillips and A. E. Tomhave.

There was an outstanding difference in the amount of herbage available on the different paddocks in the 1942 season. Expressed in Cow Days grazing per acre Ladino clover produced 198, Korean lespedeza 114, Kent wild white clover 87, and commercial white Dutch clover 79. The Kent wild white and commercial white Dutch clover paddocks were mostly Kentucky bluegrass and redtop in 1942 since both of the clovers winter-killed almost 100 per cent.

The comparative milk production by groups for the 1941 season was: Barn fed 100, pasture plus supplementary grain 95, and pasture alone 79. This data for 1942 has not yet been tabulated.

Title: Lespedeza Selection for Pasture Types.

Leaders: G. L. Schuster and C. E. Phillips

Matters of plot technique in testing strains continue to give trouble. No real progress was made in 1942.

Title: Selection and Breeding of Trifolium Species

Leaders: J. M. Watkins and C. E. Phillips.

White clover strains and varieties are being grown in nursery plots, broadcast plots and in competition with Kentucky bluegrass. Ladino clover strains are being tested with orchard grass. Tests have not been underway long enough to evaluate the strains as to yield and adaptation. Drought resistant studies conducted under greenhouse conditions have indicated differences in Ladino clover strains.

Strain tests are being conducted with red clover and crimson clover. Cumberland red clover is proving to be outstanding for Delaware conditions. An attempt is being made to find a strain of crimson clover which is both high yielding and resistant to the disease, Sclerotinia trifoliorum.

Title: The Adaptation and Use of Improved Strains of Grasses.

Leader: C. L. Phillips.

This project was started in the summer of 1942. The objective is to test improved strains of grasses as to their adaptability to conditions in Delaware and their value for pasture, hay, poultry range, etc.

Improved strains with an indicated potential value in this region will be tested in nursery rows, small broadcast plots--alone and with such legumes as alfalfa and Ladino clover, and in field tests. About seventy strains of some fourteen species were seeded in August 1942.

The Bureau of Plant Industry and the Regional Nursery of the Soil Conservation Service is cooperating in supplying strains of improved grasses for testing.

Title: Evaluating Ranges for Poultry.

Leaders: Edmund Hoffmann and J. M. Watkins.

Pullets raised on Ladino clover, mixed grasses, alfalfa, grass and clover mixture, bare ground and in confinement, laid approximately the same number of eggs per bird the first year in the laying house and there was no significant difference in mortality.

Pullets restricted to 75 per cent of full feed on Ladino, alfalfa, mixed grasses, and grass and clover were not able to gain as rapidly as pullets in confinement on full feed. There was no significant difference in the ability of the birds to utilize the various kinds of herbage used.

Two years' results would indicate that only five per cent of total feed intake can be saved by using poultry pastures.

During the coming year, the saving possible in feed cost will be investigated by depending on range for the water soluble vitamins, Vit. D, and some of the protein.

MAINE AGRICULTURAL EXPERIMENT STATION

Title: Grassland Studies

Leader: D. S. Fink

A bulletin covering seven years of grassland investigations, by the Maine Experiment Station, will be published in the near future.

Ladino clover seed, obtained from three acres of second crop Ladino clover vegetation, was produced by the Maine Experiment Station this past season. A total of 70 pounds, or more, of Ladino clover seed per acre may be expected from a good stand of second crop Ladino clover, made into hay about the middle of August and subsequently thrashed. The hay following thrashing carried good color and was superior to alfalfa leaf meal in all desirable nutrients and mineral elements, except that it contained from two to four per cent more crude fiber than is stated in the officially adopted definition of alfalfa leaf meal. Ladino clover seed production appears practical in Maine, on the basis of this information and previous experience in the production of Ladino clover for other purposes.

Ladino clover (the seed broadcast on an excellent, established sod of strawberry clover) is crowding out strawberry clover on a wet, lowland pasture. It appears that Ladino clover is adapted to far wetter land than is, perhaps, ordinarily recognized.

Grass silage trials clearly showed that Ladino clover-timothy vegetation should not be cut into a silo when it contains appreciably more than 35 per cent dry matter content, whether a preservative is to be added or not. Preservatives, phosphoric acid and propionic acid, were not sufficiently effective on material containing more than 35 per cent dry matter to produce eatable silage.

MARYLAND AGRICULTURAL EXPERIMENT STATION

Title: Methods of Improving Permanent Pastures on the Several Soil Provinces in Maryland.

Leader: W. B. Kemp.

During the season of 1941 a number of pastures of different species and different fertilization were caged to obtain estimates of both absolute production and distribution of production throughout the season. In 1942 an attempt was made to determine the extent to which dairy farmers were

succeeding in carrying out pasture practices that provided their herds with abundant pasturage throughout the season. Accordingly four farms, differing in their management practices, were chosen for detailed study. In addition, partial records were obtained from other farms.

On these farms all pastures were caged and a monthly record of cow days of pasture from each field was obtained. Also the monthly feed consumption for grain, hay, and silage was recorded. Against these records were placed milk production and change in animal weight as estimated by use of girth straps.

Before evaluating the pastures on these farms certain corrections had to be introduced. For instance, during the winter feeding period about ten per cent of the feed recorded as consumed never showed up in normal maintenance, milk flow, or change in body weight. Possibly the estimates of feed were in error or the amount of unconsumed feed was high. Also in summer a part of the pasturage estimated from cage clippings did not show up in grazing records. Consistent records were obtained by introducing graduated corrections for this latter error. The disparity between monthly clipping yields of pasture herbage and yields derived by use of the feed replacement method increased with increase in yield of herbage for a given clipping up to yields of 800 or more pounds hay equivalent. For adjusting yields of Kentucky bluegrass-white clover pasturage four per cent of the clipping yield was deducted for each 100 pounds of hay equivalent up to forty per cent deduction for 1,000 pounds per acre produced at any one monthly clipping. For Ladino clover a correction of five per cent was applied similarly. For orchard grass and red clover-hay grass mixtures the correction was six per cent for each 100 pounds up to 800 pounds.

Milk flow of any herd was corrected for dates of freshening of cows in the herd.

The most efficient pasture record was one in which one-third of all digestible nutrients for the year were obtained from pasture. Seasonal fluctuations in weight and in milk yield increased as the proportion of nutrients obtained from pasture was reduced. On all farms pasture was abundant in the spring. The curve of seasonal production was similar for bluegrass-white clover and for Ladino. However, spring growth accumulations on Ladino could be carried on the ground into the summer when pastures were short, while bluegrass could not be carried over in this way without reduced consumption by the cows. Orchard grass gave the most uniform production of palatable feed throughout the season.

Very little lespedeza was used on any of the farms where complete records were obtained. However, partial records on other farms indicated that the uniformity of pasture production on all farms would have been improved had limited acreages of lespedeza been available for pasture during mid-summer.

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

Title: Experiments at Amherst with Hay and Pasture Seeding Mixtures.

Leader: V. G. Colby.

Yields of both hay and pasture herbage on plots described in the 1941 report were lower this year than last. Plots which produced at the rate of 3-1/2 to four tons of dry matter per acre last year produced three to 3-1/2 tons this year. Reduced yields resulted notwithstanding the fact that growing conditions so far as the weather was concerned were much more favorable this past season than they were a year ago. Total rainfall for the period from March 1 to November 1, 1942, amounted to 30.55 inches, slightly above normal for this period, whereas the total rainfall for the same period in 1941 was only 22.02 inches.

These experimental results are consistent with that which has been observed in newly seeded hay and pasture lands in Massachusetts for many years. Unless weather conditions or other circumstances are extremely unfavorable, yields will be highest the year following seeding. This is true for both spring and summer seedings. Yields can be expected to fall for two to three years following the second year of maximum production until a fairly constant production level is reached which will approximate 1/2 to 2/3 of the maximum figure. Careful grazing management in pastures and regular topdressing applications of suitable fertilizers will slow up the rate of decrease, but they will not arrest it.

Managed grazing of the plots in this experiment, together with a topdressing application of 200 pounds of 40 per cent superphosphate and 325 pounds of muriate of potash per acre in the fall of 1941, did not prevent yield levels from falling in 1942.

Of the three grasses, smoothbrome grass, late maturing types of orchard grass and meadow fescue, which produced well in association with Ladino clover in 1941, only meadow fescue failed to compete satisfactorily in 1942. The total production of these grasses in association with Ladino clover was not only high but was fairly uniformly spread over the

season. Smooth brome grass and Ladino clover, for example, yielded 1,015 pounds of dry herbage in May, 1,600 pounds in June, 1,065 pounds in July, 920 pounds in August, and 770 pounds in October. These yields may be compared to those from the timothy, alsike, red clover plots which were 1,210 pounds, 1,160 pounds, 770 pounds, and 340 pounds for the same harvested dates.

Promising results were again obtained from the series in which a crop of hay was cut and the subsequent growth was grazed. A mixture of smooth brome grass, Ladino clover, and alfalfa produced 4,040 pounds of hay in mid-June, 1,065 pounds of pasturage in July, 1,015 pounds in August, and 870 pounds in October. The timothy, alsike, red clover mixture yielded 5,180 pounds of hay in late June, no pasturage in July, 970 pounds in August, and 680 pounds in October.

Some of the leafy, late maturing strains of orchard grass performed moderately well with Ladino clover, and also when alfalfa was added but the commercial strains of orchard grass were not satisfactory. In the pasture plots they were all too vigorous in their growth habits and tended to crowd out the legumes even though grazing was carefully controlled and the plots were clipped after each grazing period. In the hay plots these strains matured too early for the alfalfa.

Although the common variety of orchard grass has been frequently recommended to farmers, this grass has never found widespread favor. It has recently been recommended as a companion grass for Ladino clover. The past two years' results indicate that the reluctance on the part of farmers to grow it extensively is well founded. Except where soils are fertile and well supplied with moisture and also where grazing is carefully controlled and the means are available for clipping following grazing, disappointing results with Ladino clover and orchard grass are likely to occur. Even under such circumstances no more than three to five pounds of orchard grass seed should be sown to the acre.

In an effort to eliminate some of the undesirable features of orchard grass, breeders have developed a number of new and improved strains. Several of these were included in the test and it is from some of these strains that promising results have been obtained. The outstanding one thus far is S37, a strain developed by the Welsh Plant Breeding Station in Aberystwyth, Wales. Three strains from this source were tested: S26, S37, and S143, but S37 gave the best all around performance. It is leafy, late maturing, moderately vigorous and upright in its growth habit and it is a reasonably good seed producer. It looked well in combination with both Ladino clover and alfalfa and appeared to be adapted for use as pasture or hay and pasture combined. A satisfactory proportion of legumes to grasses has been maintained for two years in plots that were seeded with five pounds of S37 orchard grass, two pounds of Ladino clover and ten pounds of alfalfa.

Svalof's early meadow fescue, a short narrow leafed type, grew well the first season with Ladino clover, but was unable to maintain a stand throughout the second season. Commercial strains were eliminated the first season. The Svalof strain has been of interest, because it is apparently immune to leaf rust, a factor which may explain why it is more persistent than commercial strains. Although meadow fescue is apparently unsatisfactory when grown along with Ladino clover, there are indications that five to eight pounds might be seeded along with four to five pounds of a leafy strain of orchard grass or eight to ten pounds of smooth brome grass with excellent results. Meadow fescue is a fast growing grass which establishes itself quickly and would retard weed growth and yield considerable feed while the slow growing brome grass or orchard grass was becoming established.

Strains of the so-called tall meadow fescue, such as Alta tall fescue, have not performed satisfactorily. They are coarse and highly unpalatable in comparison with several of the other grasses and they offer too much competition for Ladino clover.

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

Title: A Study of Pasture Species under New Hampshire Conditions.

Leaders: Ford S. Prince, Leroy J. Higgins and Paul T. Blood.

Various lines of related work were conducted under this experiment during the year. Briefly, the project has been divided into two parts: (1) Breeding, and (2) testing of species and strains.

I. Breeding work has progressed with three species, timothy, red clover and white clover.

A. Timothy. Enough seed was available from two strains of timothy to make small plantings on a field scale, and for seeding in small plots in the nursery.

Of the field scale plantings, one was a complete failure, that of the late hay type, while the pasture type seeding was a partial success and some seed for distribution may be obtained from this plot in 1943. Both plantings were made on the Vhenal farm in Greenland, on fall prepared land, the seed having been broadcast on late snows in March 1942. It was the earlier seeding that was partially successful.

The two types selected are, as before indicated, one for late hay, a strain with tall growing and very vigorous parentage, and one for pasture a strain that is vigorous but not so tall but which develops an abundance of basal leaves. There are 40 parent plants in the late hay type and 25 in the pasture type.

Seed has again been saved from each of the parent plants in both cases and some of it has been bulked for field multiplication. This year, seed from each plant will be sown in small individual plots for observation and possibly for yield records.

The bulk seed sown in small plots in the autumn of 1941 had been produced in the greenhouse during the late winter of that year. These plots were divided into four parts, one of which was clipped each week, one every two weeks, one every month, while the fourth section was allowed to mature. The pasture type showed a much greater power of recuperation after clipping, especially where the clippings were made most frequently.

It is our purpose to multiply seed of both these strains as rapidly as possible, believing that they may have specific value for at least a limited area of New England. It is planned to seek further improvement by adding desirable plant material to and eliminating undesirable plant material from these strains.

B. Red Clover. During the winter of 1941-42 about 60 reciprocal crosses were made in the greenhouse among the F₁ progeny of the twelve original families of red clover that showed some perennial characteristics. In the summer the seed was scarified, planted in plots and later the plants were set in the field.

Since some loss in spaced plants due to winter-killing had been observed some of these plants were set in drills about six inches apart to see if loss could not be reduced. Other plants were set in checks about two feet apart and mulched with straw just before winter set in.

During the season a good harvest of seed was taken from the first planting of these perennial families. (This is the third season's harvest.) Late in the summer plants were selected, potted and placed in the greenhouse for further crossing during the winter.

C. White Clover. In this work we have chosen during past years desirable large native wild white clover plants and Ladino plants known to be hardy. These have been crossed artificially.

The F₁ generation was started in the greenhouse early in 1941 and set into the field in July of that year. In October of 1941, cuttings were taken from 14 of the plants that were the leafiest and most vigorous. These were removed to the greenhouse and during the winter backcrosses were made to Ladino parents taken from a field which had been seeded in 1937.

Seeds from these crosses were planted in the greenhouse last spring and the seedlings representing the F_2 generation were transplanted to the nursery in the summer of 1942. There were 285 seedlings in all. Cuttings were taken from the most desirable of these last autumn and removed to the greenhouse. These are now almost ready to backcross to Ladino.

Our purpose in this work is to develop a more leafy strain of white clover than Ladino, and one which may perhaps stand close grazing better. At the same time we wish not to lose any of the height characteristics of Ladino but to have a form of clover that will compete with the tall grasses when seeded with them.

In addition to the breeding work that has been conducted in the greenhouse with white clover, 16 of the F_1 plants were caged during the summer of 1942 and bees were introduced for open pollination. Seeds produced from the plants so crossed have been saved and kept separate. These will be planted in small plots, by families, in 1943, for observation as to growth characters and other desirable or undesirable characteristics.

II. Testing of Species and Strains.

A large number of strains of grasses from a variety of sources are being tested in the nursery. These include more than 100 duplicated row plantings of timothy, orchard grass, perennial ryegrass, fescues, Kentucky bluegrass, smooth brome grass and others. Amongst these are many promising sorts. We have given particular attention to timothy, especially for hay purposes. Of the timothies under test any one of the following was superior in size, leafiness and yield to the "commercial" crop which was seeded for comparison: Milton, Montcalm, S51, S48, Cb 213, Cb 224, O.A.C. No. 1 intermediate, O.A.C. No. 1 hay type, Hall's stream (local), mountainview (local), Cornell 4059, F.C. 19574, F.C. 19578, F.C. 15167, F.C. 28116, F.C. 28114, F.C. 28113, and F.C. 28111.

Of the orchard grass strains, the Welsh selections S26, S37 and S143 are leafier, and later in heading (a desirable factor) than the others under trial. Avon, O.A.C. No. 1 and CC180 are all desirable strains, however.

The so-called creeping brome grass types (smooth brome) do not creep much more in our climate than the non-creeping types. The bromes have not been seeded as long as the

timothies and orchard grass strains and it is probably unfair to draw conclusions in respect to them at this time. The same statement may be made about the other grasses.

Title: Producing the Full Roughage Requirements on New Hampshire Lairy Farms (with Special Reference to Pastures).

Leaders: Ford S. Prince and Paul T. Blood.

This experiment was outlined in 1942 as a continuation of or supplement to a pasture topdressing experiment which for many years had engaged our attention. The new project embraces in its scope the forage needs for the whole farm, but deals in some of its phases with the use of larger grasses and legumes for permanent pasture and involves plowing and reseeding, working the land with a bush and bog harrow and reseeding with various fertilizers in different amounts, and with rates of seeding and other phases of the pasture program.

One of the chief points of interest is to find out how much more productive are the hay grasses like timothy, orchard, smooth brome, perennial rye and Reed canary grass, and tall fescue than are the properly treated permanent pastures, during the hot summer period. It is conceded that even with optimum fertilizers the permanent pastures of New Hampshire are not adequate to keep high producing cows in flush milk production during July and August. Our purpose here is to determine whether one or more of these perennial grasses, carefully seeded and managed and in association with Ladino clover, will fill in this midsummer pasture gap. This so-called gap is now being filled in a variety of ways: By cutting and carrying green feed, by pasturing annual crops such as oats or millet, by feeding summer silage or by heavy barn feeding.

For these farmers who have sufficient acreage, and this includes most New Hampshire dairymen, a field or two seeded to one of the larger grasses would be a godsend, if they would supply sufficient pasturage.

This experiment was begun in 1942. It is too early yet to draw many conclusions. However, we venture a few observations on the basis of the seedings made last spring.

Smooth Brome. On the R. N. Johnson farm cows showed preference for this species in the seedling stage and consequently ate the nurse crop much shorter where brome occurred. This has not been true in other comparative seedings, or if it has it has not been observed.

Stands of smooth brome are thin. Whether we do not use enough seed or whether the seed has not been planted deeply enough, we do not yet know.

Tall Fescue. We are not enthusiastic about this grass. It is coarse, hard and apparently unpalatable. I doubt the advisability of using it in pastures in New Hampshire.

Orchard Grass. Farmers report the palatability as being good in this, the first year of our trials.

It competes too much with Ladino at the rate at which it was most commonly seeded, 10 pounds per acre. I suspect we will have to reduce the rate to 3-4 pounds where Ladino is included. We have some seeding rate tests out at three, six and nine pounds per acre. The lower rates look better from the standpoint of both clover and grass.

Perennial Ryegrass becomes established quickly, competes quite a little with Ladino and is not as palatable as timothy, orchard grass, or smooth brome.

Italian Ryegrass. In two cases where this was used as a nurse crop it has taken over, forming a dense sod and crowding out everything except orchard grass. Seeded last spring the sod now looks like an old bluegrass pasture, with little Ladino, and practically none of the other grasses except, of course, orchard. If it kills out this winter, which is possible, those areas will be without desirable vegetation in the spring. It produced more feed than oats, however, as a nurse crop, and looks as if it might make a good annual pasture (or nurse crop if the seeding rate is reduced).

In addition to our observations, yield records and other studies in connection with these tests, we will be able to secure the observations of farmers since the trials are seeded or will be on working farms in every county in New Hampshire. In some cases there is more than one farm per county, there being 15 tests already in operation.

The tests are handled in a variety of ways. In some instances a whole field may be utilized for a single new grass, with Ladino. In others a whole field may be divided into equal areas and one grass with Ladino seeded in each area or plot. Usually these single areas occupy about one acre.

In so far as possible plowing has been contrasted with seed bed preparation with a bush and bog harrow. In some cases on very rough land the bush and bog alone was used while in others plowing only was done, followed by harrowing in the

usual manner. All the tests include Ladino but in a few smaller areas birdsfoot trefoil has been utilized. In some cases a pasture mixture heavy with Ladino has been superimposed upon the seedings of individual grasses.

Farmers report that the bush and bog harrow behind a tractor saves about one third the time in preparing a seed bed. This tool has the further advantage of being usable on rough, stony or rocky land which cannot be plowed.

The field seeded in these tests will all be pastured in 1943. The plan is to cage a number of the tests this year to get comparative yield records of individual grasses and fertilizer variations and to combine with these records a summary of observations and farmers' experience in drawing reliable conclusions.

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Title: Beef Cattle Pasture Experiment with Orchard Grass.

Leader Gilbert H. Ahlgren.

Paddock 1. Ladino clover plot. Manure and 400 pounds of 0-20-20 fertilizer per acre.

Paddock 2. Heavy nitrogen. 1,000 pounds of 5-10-5 per acre.

Paddock 3. Birdsfoot trefoil. Manure and 400 pounds of 0-20-20 per acre.

Paddock 4. Kent white clover. Manure and 400 pounds of 0-20-20 per acre.

Paddock 5. Control. Given 400 pounds of 5-10-5 per acre.

The orchard grass pasture was established several years ago. It was first put under experimental rotational grazing in the spring of 1942. All plots receive one ton of ground limestone every two years. This 20-acre field of orchard grass divided into five paddocks of four acres each maintained a herd of 22 Aberdeen Angus beef cattle during the entire grazing season except for one week in September. While cow-pasture-days varied with each paddock, in general it was found that the 22 head of cattle gained a total of 6,000 pounds in weight during the season. Each acre of this pasture thus represents a return of about \$45.00 in terms of beef alone. In addition, 6-1/2 tons of hay were harvested from Paddock 2. Along with these excellent returns it was noted that this grass gave excellent growth during the early hot, dry part of the

summer when Kentucky bluegrass was almost dormant. One of the outstanding virtues of orchard grass is this ability to grow during the hot, dry portion of the summer.

Title: Comparative Yield Test and Cutting Treatments for 14 grasses and three legumes.

Leader: Gilbert H. Ahlgren.

This test was seeded in August 1941 but due to a very poor stand it was reseeded in August 1942. The grass species are as follows: Meadow fescue, tall fescue, timothy, Reed canary, brome, tall oat, orchard grass, Kentucky and Canada bluegrass, Italian and perennial ryegrass, redtop, red fescue, and colonial bent grass. The three legumes, birdsfoot trefoil, Ladino, and Kent wild white clover, were seeded across each grass in duplicate plots. Cutting heights favorable for wild white clover and for Ladino clover are to be used.

Title: Poultry Range Palatability and Adaptability Study.

Leader: Gilbert H. Ahlgren.

This test was established in Early September 1942. There are 12 perennial grasses, four annual grasses, five perennial legumes, and two annual legumes included in the test. Each grass plot is 200 square feet in area. One legume has been planted with each grass. The plots are in duplicate and so arranged that rotational grazing of the poultry flock can be practiced. An application of 1,000 pounds of ground limestone per acre was made prior to seeding. All grasses and legumes appeared to be well established last fall.

It is the purpose of this test to determine the desirability of the various grass and legume species for use on poultry ranges from the standpoint of ease of establishment, productivity, and factors of palatability.

Over-state tests have also been established in Monmouth, Cumberland, and Ocean counties on the light sandy soils of that section. The grasses in these tests are perennial ryegrass, orchard grass, timothy, brome grass, and tall fescue. Legumes which have been run in strips across the grass plots are as follows: Red clover, Ladino, white

clover, alsike, and alfalfa. Sainfoin is included in one of these tests. The object is to determine adaptation to soil conditions and the grazing value for poultry. These tests were established in the fall of 1942.

Title: Grass and Legume Introduction Nursery.

Leader: Gilbert H. Ahlgren.

Observations and notes have been taken on about 250 strains and species of grasses and legumes. Estimates of their value for pasture, hay, erosion control, mulch, and lawns have been made. Better strains of outstanding species have been selected for further testing here at the station and also in over-state tests.

Title: Uniform Grass and Legume Nursery.

Leader: Gilbert H. Ahlgren.

Studies on the row and small plot tests established in 1941 are being continued. Data on growth habits, and yield records have been taken this past season. Due to the slow establishment of the sod plots and their weedy condition it is felt that this data is unreliable.

Differences were found in growth habits and yields within and between grass species. The grass species in this test are: Kentucky bluegrass, Red canary, timothy, Italian ryegrass, perennial ryegrass, meadow foxtail, meadow fescue, brome grass, red fescue, redtop, velvet bent grass, and Canada bluegrass. This is a cooperative uniform grass nursery test with the Bureau of Plant Industry, U. S. Department of Agriculture.

Title: Species Adapted for Hog Pasturage.

Leader: Gilbert H. Ahlgren.

Twelve grasses were seeded in 1/12 acre plots for comparative testing of suitability for grazing hogs. An overall seeding of Ladino clover was made. The planting was made in early September 1942. Excellent stands of all species were noted in the fall. These plots will be put under grazing this spring or early summer.

Tests of domestic ryegrass sown alone and in combination with alfalfa and red clover were started on 1/2 acre plots this fall.

Title: Strain Tests of Orchard Grass and Brome Grass for Dairy Cattle Pastures.

Leader: Gilbert H. Ahlgren.

Two paddocks each four acres in size were planted to strains of orchard grass and brome grass in early September 1942. Three strains of orchard grass with an overall seeding of Ladino clover are being tested in one of the paddocks. The orchard grass strains are S-26, Brage, and commercial. In the other paddock 2683-1, Auchenbach, and commercial brome grass will be compared. There is an overall seeding of alfalfa in this paddock. Each grass strain is planted on 1-1/3 acres with no replications. The plots are set up for rotational grazing. A fairly good stand of all strains of grasses and the legumes was secured last fall.

Title: Demonstration on Establishment of Improved Species in Permanent Pastures.

Leader: Gilbert H. Ahlgren.

The cooperative farm pasture demonstrations located in northern New Jersey, in Morris, Sussex, and Warren Counties, as discussed in the 1941 report, were continued during 1942. These demonstrations have continued to indicate the superiority of certain of the newer grasses over the ones commonly used in seeding mixtures, particularly on the less desirable sites. From all indications, it is possible to establish a fairly permanent yet palatable pasture sod on fields where only undesirable species have grown previously.

During 1942, a series of six demonstrations were started in Burlington County to compare the forage yields obtained from pastures seeded with different grass and legume mixtures, and also with different fertilizer treatments. Three classes were set up as follows:

1. Bluegrass - White clover pastures receiving no fertilization.
2. Bluegrass - White clover pastures receiving from medium to heavy applications each year of commercial fertilizer and lime, when needed.
3. Timothy, orchard grass-Ladino clover pastures receiving ample applications of commercial fertilizer and lime.

Two fields were selected for each class.

The final report is not available as yet on the results obtained from these different types of pastures. However, the Ladino clover-timothy, and orchard grass pastures did produce

the higher yield of dried forage per acre. The rainfall during July and August was well distributed and, therefore, they were productive throughout the entire growing season. The well fertilized bluegrass-white clover pastures produced several times more forage than the unfertilized pastures containing the same general forage species.

The number of cow days plus the amount of lime, fertilizer, and manure applied are all being considered in evaluating the productiveness of these pastures.

Title: Belle Ellen Pasture Experiment.

Leader: C. E. Bender.

The Belle Ellen pasture area, comprising 45 acres divided into 11 pastures under rotation management, carried 54 head of Holstein milking cows for 40.5 days and 52 head of Guernsey milking cows for 137.5 days. These pastures produced 2605.1 pounds of four per cent fat corrected milk per acre. After deducting for hay and grain fed, the animals secured 1629.8 pounds of total digestible nutrients per acre from the pastures during the grazing season of 178 days.

Title: Fertility Levels on Dairy Farms.

Leaders: C. E. Bender and Firman E. Bear.

A complete description and methods of procedure for this project may be found in the 1941 Annual Report, Page 83.

Rainfall during the growing season averaged nearly two inches more per month than for the previous 35 year period at Sussex, New Jersey. The pastures averaged 150.5 one thousand pound cow days per acre for a grazing season of 178 days. While the fertilization and clipping yields are given in Table 19 for each of the four plots in each pasture, no attempt was made to graze each plot separately. All grazing data is reported for each pasture as a unit.

Title: Pasture Fertilization in Relation to Carrying Capacity (Wyker Farm)

Leader: C. E. Bender

The Wyker Farm area in 1942 produced 1899.5 pounds of total digestible nutrients per acre. A total of 62 Holstein and Guernsey dairy replacement animals grazed the 44 acres under rotation management and variously fertilized for an average of 173.6 one thousand pound cow days for a grazing season of 144.1 days. The animals gained 185.4 pounds of live weight per acre. The average cost per pound gain while on pasture was .03 cents.

B15	3.441	6.2	0 tons	Manure plots	250 P ₂ O ₅	80.8	3621.4
		6.5	2-1/2 tons			82.4	3746.2
		6.6	5 tons			81.7	4356.0
		6.6	10 "			81.6	3338.6
Ladino Pastures							
B2	4.27	6.4	0 lbs. P ₂ O ₅	Phosphate plots	250 lbs. KCL	Failure of new seeding.	
		6.3	125 "			No yield samples taken.	
		6.2	250 "				
		6.1	500 "				
B4	7.28	6.3	pH natural	Lime plots	250 lbs. P ₂ O ₅	New seeding in wheat.	
		6.4	pH 5		200 " KCL	No yield data taken.	
		6.5	pH 6				
		6.6	pH 7				
B11	4.237	6.2	0 lbs. CaCN ₂	Nitrogen plots	250 lbs. P ₂ O ₅	81.5	4907.7
		6.3	62-1/2 lbs. CaCN ₂		200 " KCL	82.4	6098.4
		6.5	125 lbs. CaCN ₂			81.5	6135.5
		6.6	250 "			78.5	5430.5
B13	3.861	6.4	0 tons	Manure plots	250 lbs. P ₂ O ₅	80.0	2904.0
		6.4	2-1/2 tons		100 " KCL	81.3	4559.3
		6.3	5 tons			82.0	4830.6
		6.0	10 "			83.0	4094.6
B14	3.25	6.5	0 lbs. KCL	Potash plots	250 lbs. P ₂ O ₅	83.4	2410.3
		6.3	100 "			84.8	4407.6
		6.0	200 "			87.0	4407.6
		6.4	400 "			89.1	4936.8

Title: A Comparison of Acetic Acid, Fed in the Form of Triacetin, with Glucose as a Nutrient in Feeds

Leaders: T. B. McManus, C. B. Bender, and O. F. Garrett.

A study of the nutritive value of two balanced rations has been conducted. The first of these rations, called the basal ration, contained 15 per cent glucose. The second ration, designated as ration No. 2, contained acetic acid in the form of triacetin equal in caloric value to the glucose of the basal ration. They were alike in all other respects. The two rations were fed to albino rats, and the food intake was controlled by the method of paired feeding.

A comparison of the efficiency of the rations in supporting growth of immature rats showed that the two rations were equivalent in this respect.

No difference in the rate of metabolism of the rats on the two rations could be detected.

A study of the metabolizable energy of the two rations revealed that the energy of the basal ration was 94.5 per cent metabolizable and that of ration No. 2, in which acetic acid as triacetin was substituted for an equivalent amount of glucose, was 94.3 per cent metabolizable. The difference between the two rations was not significant.

There was no significant difference in the excretion of volatile acids in the urine of rats on the two rations.

Acetic acid, in the form of triacetin, fed over a 7-month period had no harmful effect on the animals.

The basal ration and ration No. 2 were, therefore, exactly equivalent in value when used to support growth and for maintenance of rats. From this, it is concluded that acetic acid, in the form of triacetin, was utilized with a degree of efficiency equal to that of glucose.

NEW YORK (CORNELL) AGRICULTURAL EXPERIMENT STATION

Title: Breeding Timothy for Hay and Pastures.

Leader: C. H. Myers.

Five pasture type strains of timothy have been sent to agronomists for testing in the Eastern United States and Canada. The tests are located at Quebec; Lexington,

Kentucky; Amherst, Massachusetts; Orono, Maine; Storrs, Connecticut; Lafayette, Indiana; and at Ithaca, New York. Sufficient time has not yet elapsed to obtain adequate data on the performance of these strains. At Ithaca, New York, strain 4030 appears to be especially promising as a pasture type timothy.

Title: Breeding Alfalfa for Winter Hardiness and Yield for Hay and Pasture.

Leader: C. H. Myers.

Cornell pasture type alfalfa strains 13 and 21 were tested at the Ohio Agricultural Experiment Station, in cooperation with Doctor C. J. Willard. According to Doctor Willard, strains 13 and 21 were noticeably outstanding in resistance to leafhopper injury in both 1940 and 1941 as evidenced by their greener color in July and August. In a nursery row test at Ithaca, New York, several of the Cornell pasture type alfalfa strains looked promising with respect to habit of growth, quick recovery after cutting, and green color.

Title: Pasture Seeding Mixture Experiment (Mount Pleasant Farm).

Leader: R. B. Musgrave.

Yield and chemical composition were determined as described in the 1941 Annual Report. Four clippings in 1942 gave higher yields than were obtained in 1940 or 1941. The three high yielding mixtures contained Ladino clover as one ingredient. Botanical composition data indicate that this clover was the greatest single contributor to the yield of mixtures in which it occurred. Wild white clover is the legume common to the three lowest yielding mixtures. The other mixture in the study gave an intermediate yield. It ranked high in 1940 and 1941 because of the presence of red and alsike clovers, but in 1942, these had vanished, leaving only wild white clover and their residual nitrogen to stimulate grass growth.

Chemical composition data show the high yielding mixtures to be highest in percentage nitrogen and calcium. Botanical composition of the mixtures did not appear to have any effect on the percentage of potassium and phosphorus present.

Title: The Value of Birdsfoot Trefoil as a Pasture Legume in New York.

Leader: H. A. MacDonald.

Investigations relative to the possible agricultural use of birdsfoot trefoil (Lotus corniculatus) as a forage legume for this area, as reported in 1941, were continued. The 1942 production results were obtained from all seedings made in 1939 and thereafter. Several trials were initiated or extended in the present year including (1) study of inoculating methods, (2) methods of renovating old pastures, (3) comparison of various strains of birdsfoot trefoil for pasture use, (4) selection of new strains, and (5) evaluation of pasture experimental techniques for the valid comparison of pasture plants.

Additional farm trials were initiated in the spring of 1942 covering those parts of the state omitted in 1941. At the present time, trials are located in all agricultural counties of New York State. Those seeded in 1941 gave evidence of good promise in 1942. These will be observed over a period of years.

The tests at the Experiment Station in 1942 gave higher yields from spring than from fall seedings. August seedings gave satisfactory results in some instances. The season was such that good growth was made. Birdsfoot trefoil gave superior yields when seeded with the more open sward-forming grasses, such as Kentucky bluegrass, Canada bluegrass, orchard grass, and creeping red fescue. When seeded with Kentucky bluegrass, certain selected strains of birdsfoot trefoil were superior to all others as in 1940 and 1941. At both the Caldwell Field and Mount Pleasant Stations, birdsfoot trefoil gave pasture yields superior to wild white clover in 1942. The problem of wild white clover encroachment is becoming serious in the older plots, and this, together with the problem of finding a suitable harvest method, makes the valid comparison of various legumes a matter of considerable difficulty.

Title: The Study of Plant Associations for Pasture Purposes.

Leader: D. B. Johnstone-Wallace.

The experimental plots of grasses and legumes grown alone and in association on field plots clipped with a power lawnmower have been continued except when curtailment has been necessary in consequence of the shortage of labor. Results obtained

tend to confirm those obtained in previous years. It will now be possible to obtain average figures from a sufficiently long period to provide useful information.

Although differences in total yield of dry matter produced by different species or varieties of grasses grown in association with wild white clover are not as large as would be expected under the conditions prevailing, they indicate that Kentucky bluegrass and creeping red fescue are outstanding.

Wide differences are obtained when species and varieties of legumes are tested in association with Kentucky bluegrass, and results show that several varieties of wild white clover, Ladino white clover, New York wild broad leaved birdsfoot trefoil, and New York wild narrow leaved birdsfoot trefoil are the outstanding pasture legumes under the conditions prevailing.

In mixtures intended for a combination of silage and pasture production, the outstanding grasses are certain varieties of orchard grass including Aberystwyth Sl43 and Svalof brage, smooth brome grass and Kentucky bluegrass. In the species and varieties of legumes tested, Ladino white clover has been outstanding, but the results obtained in 1942 with New York wild birdsfoot trefoil in association with Sl43 pasture orchard grass were extremely promising and showed an extraordinary increase from the preceding year's results.

Title: Pasture Survey of New York.

Leader: D. B. Johnstone-Wallace.

The work on this project was seriously curtailed by restrictions on travel by automobile, but investigations were continued, especially in Sullivan and Monroe Counties.

Title: The Influence of Grazing Management upon the Yield, Botanical Composition, and Chemical Composition of Pasture Forbage.

Leaders: D. B. Johnstone-Wallace, L. A. Maynard, and Keith Kennedy.

This investigation was continued in spite of the difficulties resulting from the departure of Keith Kennedy on military service. The season was unusually favorable for growth, but the results were similar to those obtained in 1940 and 1941.

The better type of sward and much greater yield produced from plots cut with a power lawnmower to within approximately 1/2 inch of the ground surface to simulate actual grazing conditions,

compared with plots harvested with a sickle-bar mowing machine set to cut to within approximately two inches of the ground surface, is an indication of the danger of drawing conclusions from pasture experiments in which the methods of cutting are not given.

Title: The Influence of the Grazing Habits of Cattle on the Composition, Consumption, and Utilization of Pasture Herbage.

Leaders: D. B. Johnstone-Wallace and Keith Kennedy.

The results obtained from this investigation were presented at the meetings of the American Society of Agronomy at St. Louis, Missouri, in a paper by D. B. Johnstone-Wallace and Keith Kennedy entitled, "Grazing Management Practices and Their Relationship to the Behavior and Grazing Habits of Cattle".

Title: Poultry Pastures.

Leaders: G. F. Heuser and L. C. Norris in cooperation with D. B. Johnstone-Wallace and J. K. Wilson.

A. Pastures. On June 24, 1942, four lots of Single Comb White Leghorn pullets, eight to 10 weeks old were placed on pasture and grown for three months. Three lots were on Ladino clover and one lot on an average poor pasture consisting mostly of Kentucky bluegrass, wild white clover and weeds. Due to the wet season the poor pasture was greener than average and the Ladino pasture very lush. As far as gains in weight were concerned there were no significant differences between any of the lots.

However, the birds on the poor pasture ate 0.76 pounds or 5.9 per cent more feed than the corresponding birds on the Ladino pasture. Where the feed was restricted by keeping the feeders closed in the forenoon the birds ate 0.73 pounds or 5.8 per cent less than where the feeders were open all the time.

Because of the above differences in food consumption, there were also differences in the amount of feed required to produce a pound of gain. The poor pasture required 0.41 pounds or 5.6 per cent more feed to produce a pound of gain than the Ladino pasture. The birds with their feed restricted required 0.31 pounds or 4.6 per cent less feed to produce a pound of gain.

A ration modified by omitting alfalfa meal gave just as good results on pasture as the complete ration including the same.

With very few exceptions the birds on Ladino clover were very deeply pigmented, whereas the birds on the poor pasture were quite variable in this respect.

B. Silage. Silage made from a mixture of Kentucky bluegrass and wild white clover was fed to Single Comb White Leghorn hens from December 23, 1941, to May 27, 1942. This was given at the rate of four pounds for 100 hens a day except in one lot where ad libitum consumption was allowed. In two lots the ration did not contain alfalfa meal; in three lots the basal ration contained alfalfa meal.

There was no influence of the silage upon egg production or body weight during this period.

Hatchability was improved by the feeding of silage. With the ration not containing alfalfa meal 80 per cent of the fertile eggs hatched, while the silage supplementation increased this to 86 per cent. With the ration containing alfalfa meal 81 per cent of the fertile eggs hatched as compared with 90 per cent for the silage-supplemented ration.

A marked effect was noticeable on the color of the egg yolks as observed when broken into a dish. All the pens receiving silage showed more deeply pigmented yolks which could be detected by the average observer. The yolk color (based on a scale ranging from 0 for white, to 24 for deep orange) produced on rations without alfalfa showed a color intensity of 11.0; those produced on a restricted amount of silage 13.2 and those produced with ad libitum feeding of silage 14.2. The lots receiving silage could also be detected in the candling process by the larger proportion of visible yolks. However, the differences were not so marked as when the eggs were broken out of the shell.

Title: The Alfalfa Snout Beetle Investigation

Leaders: H. H. Schwardt, C. G. Lincoln and L. L. Newsom

Baits for control of the alfalfa snout beetle have been further improved and new formulae have been developed. The soymeal-sugar-formalin-sodium fluosilicate bait has proved far more effective when formed into small pellets. The formed bait has greater resistance to adverse weather conditions and therefore remains effective longer in the field. A bait containing soy-meal, chopped apples, formalin, and sodium fluosilicate proved as effective as soymeal pellet or raisin shorts bait, and has

the considerable advantage of requiring no sugar. Baits using a sugar beet pulp base were greatly improved by the addition of a small amount of soybean flour.

Title: White Grubs and Other Forage Crop Insects.

Leaders: H. H. Schwardt, L. D. Newsom and R. F. Pendleton.

A method for rearing the clover root borer and introducing it into greenhouse grown red clover plants has been developed. In preliminary tests with artificially infested plants reductions in yield and longevity have been shown. Field plots of red clover treated with various soil fumigants, soil poisons and fertilizers all developed heavy borer populations.

The European Chafer Amphimallon majalis has been introduced into Wayne County, New York and may become an important pest of forage crops as its range extends. Its habits are essentially similar to those of our native white grubs except that the adults take almost no food, and the life cycle is completed in one year. The larvae have been found attacking several common lawn and pasture grasses as well as both red and white clover. Soil fumigation with ethylene dichloride emulsion has given effective control of the larvae in lawns.

Studies on the effect of drought on the pupal stage of Pyilophaga fusca indicate that soil moisture is an important factor influencing survival during this stage. Pupae kept in soil having 13 per cent of moisture suffered a mortality of 64 per cent. Only 16 per cent died in soil with 26 per cent moisture, and at 38 per cent of moisture the mortality was 28 per cent.

PENNSYLVANIA AGRICULTURAL EXPERIMENT STATION

Title: A Study of the Practicability of Commercial Production of Fescue and Other Grasses and Forage Crop Seed in Pennsylvania.

Leaders: J. K. Thornton, C. C. Wernham, J. E. Nicholas, and J. E. McCord.

This project covers the production of new strains under the forage crop breeding program of the Department of Agronomy; development of practical methods of disease control in cooperation with the Department of Botany; seed conditioning problems, including cleaning and drying in cooperation with

the Department of Agricultural Engineering; and securing of records on commercial seed production together with the possibilities for development of cooperative marketing organizations by the Department of Agricultural Economics.

Performance records were obtained during the past season on sixteen orchard grass strains; twelve red fescue strains; two each of meadow fescue and crested wheat grass; one each of annual ryegrass, perennial ryegrass, and Canada bluegrass; and four strains of birdsfoot trefoil.

New grass production plots were seeded in cooperation with the Bureau of Plant Industry, U. S. Department of Agriculture, in May 1942. Selections of orchard grass, meadow fescue, red fescue, Reed canary, timothy, brome, crested wheat, redtop, tall oat, and Kentucky bluegrass were included. Seed yields and other performance records will be obtained in 1943 from both row and broadcast seedings. Forage yields will be obtained from each of the grasses seeded, alone, with alfalfa, with Ladino clover, and with birdsfoot trefoil.

A number of very desirable appearing creeping red fescue strains were seeded in increase plots. Several of these strains have wide leaves as contrasted to the narrow leaves of most fescue selections. It is intended to make a blend of the seed of the most desirable of these selections.

Seed production is being encouraged for red fescue, orchard grass, and certain local strains of red clover. About forty acres of fescue were harvested in Pennsylvania in 1942. Over two hundred and fifty acres of the Penn State blend of chewings fescue and of creeping red fescue have been seeded by Pennsylvania farmers, of which at least one hundred and fifty acres will be harvested in 1943. In addition there are twenty to twenty-five acres of Brage orchard grass in the State.

In planting, the grass seed is mixed with a combination of ground limestone and superphosphate and planted with the fertilizer attachment of a corn planter immediately after seeding a small grain. After seeding the grass the entire field is cultipacked to firm the soil over the seed. The small grains act as a nurse crop and a cash return is obtained from the land the same season in which the grass is planted. The following year the grass, which is in rows, is cultivated and later at harvest time combined for seed.

"Silver top" disease has become a serious menace to the production of red fescue and other grass seeds. This disease prevents seed development and drastically reduces yields. The loss of seed may run as high as 100 per cent. Our experiments show that "silver top" can be controlled by burning the seed

fields during the latter part of March, shortly before new growth starts. There is some spread of the disease from unburned to burned rows up to the time of seed harvest. All seed producers have been advised to burn over their seed fields and other nearby grass each spring. The yield of seed on burned was 280 pounds against 214 pounds on the unburned fescue.

Epichloe typhina was discovered in several clonal lines Festuca rubra genuina imported from Beno Bálent and Sons, Budapest, Hungary. In lieu of the systemic nature of this fungus, all clonal lines exhibiting disease symptoms were destroyed.

The commercial seed dryer which was developed at this station for drying grass seed by means of infra-red lights was used again. Although the capacity of the dryer was only 120 pounds per hour on fescue seed it was possible to reduce moisture in a small sample of seed from 17 per cent to less than 10 per cent in two minutes, 35 seconds. One seed grower has made plans to build a dryer of this design with a much greater capacity, which can be used for custom drying.

A difficulty in cleaning the seed was encountered during the past season. This problem was partially solved by use of a hammormill to break up the fescue seed clusters before using the seed cleaners. More information is being obtained on seed drying and conditioning.

Title: Testing and Breeding Grasses for Pasture and Other Uses.

Leaders: J. E. Thornton and C. C. Wernham.

This project is being continued as in previous years. New selections of creeping bent, Kentucky bluegrass, and creeping red fescue were made. Yield and quality measurements, as previously reported, were made on all selections. No expansion of this phase of the work is being planned for the duration of the war.

Two treatments for control of diseases of fine turf have been developed during the past season. Thiosan (50 per cent Tetra methyl Thiuram disulphide) used at the rate of 4-1/2 to six ounces per 1,000 sq. ft. at intervals of ten days to two weeks gave excellent control of Dollar Spot (Sclerotinia homoeocarpa Bennett) and Large Brown Patch (Rhizoctonia solani Kuhn). However, if Dollar Spot is not present, Large Brown Patch and the "melting out" diseases caused by the helminthosporium, Colletotrichum complex,

can be effectively controlled by using hydrated lime at the rate of ten pounds per 1,000 sq. ft. whenever the disease appears. The lime is applied dry and poled in. After twenty-four hours it is washed in.

A new disease, designated as "Copper Spot" to distinguish it from Dollar Spot appeared on the station plots this last season. The organism responsible is a species of *Gloeocercospora*, probably *Gloeocercospora sorghi* Edgerton and Bain. One of the characteristic features of this disease is its ravaging effect on certain strains of velvet bent (*Agrostis canina* L.) which are quite resistant to Dollar Spot. The disease is also severe on certain strains of colonial bent (*A. tenuis* Sibth) and creeping bent (*A. palustris* Huds.). Preliminary attempts at control have not been successful.

Greenhouse pot experiments on the relation of soil nutrient ratios to Large Brown Patch disease control (1941 Annual Report, Page 105) revealed no direct effect of any series of nutrients on disease incidence. Effect is limited to the processes which may aid the turf in attaining vigor of growth.

Lotus corniculatus in preliminary trial plantings on four hillside pastures, where the sod was broken with a disk, is becoming established, but have not been grazed yet. This legume shows promise for those pastures which are too dry to produce white clover.

Title: Testing and Breeding Strains of Red Clover.

Leader: J. K. Thornton.

Tests conducted during the past five years indicate that certain locally grown Pennsylvania strains of red clover can be classed as superior in forage yield, disease resistance and persistence. Seed increase of these strains is being encouraged.

Two commercial blends of red clover, Midland and Cumberland, have done well for several years and they are being recommended for this year's seedings.

Title: Pasture Management Studies (Montrose, Pa.)

Leaders: S. I. Bechdel and C. F. Noll for The Pennsylvania
Agricultural Experiment Station
S. R. Skaggs and M. A. Hein for the Division of
Forage Crops and Diseases, Bureau of Plant
Industry, U. S. Department of Agriculture

Work was started in Susquehanna County in 1940. This work was based on experience gained from the eleven years' work done at Kylertown, Clearfield County, Pennsylvania. A final report on the Kylertown work will be printed early in 1943.

Results of the 1942 season show a slight advantage from a continuously grazed permanent pasture over similar pasture on which grazing was controlled to keep the grass from two to four inches in height throughout the season. One-half of a third pasture was cut in June for grass silage and grazed thereafter. Grazing from this pasture was almost equal to the pasture on which grazing was controlled.

A pasture made up of orchard grass, timothy, tall meadow fescue and Ladino, red and alsike clovers grown in a five year crop rotation produced about 50 per cent more than did the permanent pasture continuously grazed. One plot of the crop rotation pasture which was cut for hay in the middle of June produced as much during July and August as the continuously grazed permanent pasture. Production after cutting of the former for the remainder of the season was almost equal to that of the permanent pasture for the entire season. The most desirable feature of these crop rotation pastures is the large amount of good grazing produced during the hot summer months when the permanent pastures are at their worst. Even after a good hay crop is cut there is fair production during this time.

Yields were taken for the first time on a series of grass-legume combinations for hay. Two crops were cut. Results from these plots are as indicated in Table 20.

Seedings were made for a series of grass strain plots using several of the most promising strains of timothy, orchard grass, meadow fescue, and smooth brome grass in combination with legumes. Excellent stands were obtained and the results during the next few years should give some valuable information as to the adaptation and usefulness of the grass strains being studied.

Table 20. Hay and aftermath yields from grass-legume plots, Montrose, Pa. - 1942.

Plot Nos.	Crop	Pounds airdried grass per acre (Average of three plots)			
		Hay cut 6/25/42	Aftermath: cut 8/22/42	Total	
1/15/29	: Red, alsike and timothy	:: 3676	: 1770	: 5446	
2/16/30	: Alfalfa alone	:: 2861	: 1945	: 4806	
3/17/31	: Alfalfa and timothy	:: 3171	: 1513	: 4684	
4/18/32	: Alfalfa and orchard grass	:: 2406	: 948	: 3390	
5/19/33	: Alfalfa and meadow fescue	:: 2552	: 1205	: 3757	
6/20/34	: Alfalfa and smooth brome	:: 2268	: 921	: 3189	
	: grass	::	:	:	
7/21/35	: Alfalfa and tall oats	:: 2816	: 1291	: 4107	
	: grass	::	:	:	
8/22/36	: Alfalfa, timothy and	:: 3177	: 1958	: 5135	
	: Ladino clover	::	:	:	
9/23/37	: Alfalfa, timothy and	:: 3702	: 1414	: 5116	
	: alsike clover	::	:	:	
10/24/38	: Orchard grass and Ladino	:: 2812	: 1445	: 4257	
	: clover	::	:	:	
11/25/39	: Orchard grass and birdsfoot	:: 2161	: 756	: 2917	
	: trefoil	::	:	:	
12/26/40	: Timothy and Ladino clover	:: 2157	: 1865	: 4022	
13/27/41	: Timothy, redtop and Ladino	:: 2223	: 1829	: 4052	
	: clover	::	:	:	
14/28/42	: Timothy, Canada bluegrass	:: 1961	: 1886	: 3847	
	: and Ladino clover	::	:	:	
	:	::	:	:	

Title: Fermentation of Alfalfa Silage

Leaders: R. E. Stone, F. K. Murdock, H. L. McAuliffe and
S. I. Bechdel.

Biochemical and bacterial studies have been made on 32 alfalfa silages during the period from October 1938 to December 1942. Various treatments such as phosphoric acid, molasses, salt, Silogerm, and wilting were used and in most cases the fermentation was followed by serial analyses from the original chopped alfalfa to the final product when fed. The results include silages made under various weather conditions and from first and third cuttings of alfalfa. Some of the silages were put up in ordinary commercial silos and the rest in small experimental silos five feet in diameter and 20 feet high, artificially

weighted with oil drums filled with water. All silage which was produced with the exception of a few treatments that gave a large amount of spoilage was fed to dairy cattle. Quality of the resulting production was judged on the odor, palatability to the cows and, when possible, controlled feeding tests.

All silages underwent a typical lactic acid fermentation irrespective of treatments and after the first two days contained principally lactobacilli. The flora was not changed to any determinable degree by the addition of large amounts of phosphoric acid, salt, molasses or Silogerm.

An adequate supply of fermentable sugar present either in the original plant or added in some form was found to be the most important single factor to insure adequate preservation. If there is enough acid formed to bring the pH to below 4.2 the silage will usually be satisfactory. If the pH is not below this value and there is no reserve sugar remaining for the bacteria to attack, the lactic acid bacteria attack the lactic acid itself converting it to acetic acid with consequent slow rise in pH and decreasing quality.

Eighty pounds of molasses per ton of silage gave the most dependable preservation of alfalfa silage. Ground corn and cob meal at the rate of 200 pounds per ton was also quite satisfactory. Wilting the alfalfa in the sun before raking was found to be a reasonably effective method of preservation. In three silages treated in this manner the moisture contents ranged from 65 to 68 per cent instead of the usual 70 to 75 per cent and were found to contain more reducing sugar than the unwilted controls.

Phosphoric acid in the amount of 16 pounds per ton produced a satisfactory silage if the plant material was not too low in fermentable sugar as was demonstrated in the case of a rank first cutting of alfalfa. Salt alone did not provide adequate preservation but did appear to have some beneficial effect.

Artificial inoculation with lactic acid bacteria using a commercial preparation, Silogerm, did not aid in preservation of silage. Lowering moisture content by the addition of inert or semi-inert material such as dry hay or corn stover aided preservation somewhat but did not produce a high quality product.

The preservation of carotene in silage does not seem to be associated with any particular type of fermentation or method of treatment. Even in the case of silages that showed considerable spoilage due to a low pH, the carotene was well preserved. Although the wilted silages naturally carried a little less carotene than unwilted ones, the amount retained was considerably greater than is found in seed cured hays.

A severe loss of carotene was noted in some but not all of the silages prepared with phosphoric acid. The carotene was consistently well preserved in silages preserved with 80 pounds of molasses and studies this last summer indicate that this factor was equally well preserved in silage treated with 200 pounds of corn and cob meal per ton of green forage.

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION

The pasture research at the Rhode Island Station other than that carried on in cooperation with the Pasture Laboratory was completed last year and the results obtained were published.

VERMONT AGRICULTURAL EXPERIMENT STATION

Title: Relative Value of TVA Phosphate on Pasture and Meadows.

Leader: A. R. Midgley

The productive capacity of TVA metaphosphates such as potassium, calcium, and calcium-potassium, are being compared with ordinary single and triple strength superphosphates on hay and pasture.

Results strongly indicate that the metaphosphates are equal to superphosphates as fertilizers. This is particularly true on pastures where deep penetration of surface applications is not very necessary. Metaphosphates were quite beneficial for the spreading of white clover which is essentially a surface feeder. Calcium metaphosphate seemed to penetrate the soil more slowly than potassium metaphosphate or superphosphate. Since hay plants (timothy and red clover) are usually deeper rooted than pasture plants (bluegrass and white clover) the latter responded more quickly than the former to topdressings of calcium metaphosphate, especially during the first year.

The physical condition of some TVA metaphosphates is quite unsatisfactory. The potassium metaphosphate, for instance, is so finely ground that it is almost impossible to apply it broadcast

on pastures. It readily blows away while spreading and its fine condition promotes increased fixation in the soil because of such intimate soil contact. It also tends to harden in the bag on storage.

Title: Birdsfoot Trefoil Plantings.

Leader: A. R. Midgley.

Considerable attention is being given to the growth of birdsfoot trefoil with a limited amount of lime and fertilizer on many of the poorer Vermont pastures. A number of small plantings have been made on different pasture areas in the hope that these might become established and spread to other nearby pastures. Perhaps the two most important factors which limit its growth and spread is poor inoculation and excessive competition by more rapidly growing plants. When it is planted with a heavy seeding of red and alsike clover, a poor stand usually results, because the clover grows very rapidly during the first and second years and thus crowds out the birdsfoot trefoil. The stands have not been established long enough to permit further conclusions.

Experiments have been conducted to determine ways in which birdsfoot trefoil might best be established in pastures. In nature, many plants become established from seed scattered from droppings of grazing cattle. In the fall of 1941 a comparison was made between (1) feeding the seed to dairy cows by placing them in the grain, then spreading the manure over a known area, (2) mixing the seed with an equivalent amount of manure just previous to spreading, and (3) applying the seed directly to prepared land, then spreading the same amount of manure on top. The experiment was conducted in the fall months during the time when grazing animals usually obtain the seed and spread it in their droppings. The experiment was repeated once during August, once during September, and once during October, on land that had been prepared in the summer. The following spring and summer, counts were made to determine the extent of germination and growth of the plants. Results show that seed planted on prepared land was better than adding the seed directly to the manure, or indirectly via the cow. Most of the seed tended to remain in the pieces of manure on top of the soil (manure or seed was only lightly harrowed in). In this position the seed made poor contact with the soil and was subjected to too much drying. Of course, this

method of applying manure is quite different from that of the cow on pasture. The cow deposits much larger amounts of feces in one place and the mass does not dry out so completely. Furthermore, the amount of seed present in this mass of manure, deposited by cows pasturing on these plants when the seed is ripe, is very large indeed and may account for the success under natural conditions. It would seem that seeding via the cow is a waste of valuable seed, since enough seed for an acre would in the manure ordinarily cover only a few square yards. In view of these results, it does not seem advisable to feed the seed or mix it with manure for fall seedings. Much better success has been obtained from spring seeding in the usual way on prepared land.

Title: Pasture Improvement Studies.

Leader: A. M. Midgley.

The productive capacity of the same fertilizer applied on (1) good, (2) fair, (3) poor pasture lands having different degrees of slope, and (4) meadows are being compared on the same farm. Results show that the most efficient use of fertilizer and the greatest crop yields are obtained when the fertilizer is applied on the better pasture or on meadow land. As fertilizers become increasingly scarce, they should be concentrated on the better pasture lands for maximum food production. The best and most responsive pasture land is usually more level, contains more organic matter and retains more moisture. It uses applied fertilizer to better advantage than the steeper, poorer pastures.

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

Title: Pasture Fertilization Studies.

Leaders: F. V. Schaller, G. G. Pohlman, R. M. Smith,
H. O. Henderson and R. A. Ackerman

Small Plot Experiments. The 1942 season was, in general, quite favorable and considerable response to lime and fertilizer was noted. In all cases the white clover content of the treated pastures increased and there were usually slight increases in bluegrass. Pasture plots treated in 1930 and 1932 with lime and fertilizer still show increased yields and better quality herbage than untreated plots. There are, however, definite indications that these plots are gradually becoming poorer and that additional treatment would be desirable for greater returns.

The three areas used for study of rate and frequency of application of superphosphate showed increases in yield which were in almost direct proportion to white clover content. These areas were first treated in 1939 and white clover is the principal desirable species which has come in since treatment. At Milton, on Monongahela silt loam soil, the highest yield in 1942 was obtained from the plots which received 800 pounds of superphosphate, half of which was applied in 1939 and the other half in 1941. These plots had 41 per cent white clover and yielded over three times as much as the untreated plots. At Lewisburg, on the Frederick silt loam soil, the early part of the season was rather dry and both the clover content and yields were relatively low on all plots. Increases in yield varied from 12 to 15 per cent on the plots receiving 400, 800, or 1200 pounds. Split applications were no better than single applications. On the Westmoreland silt loam soil at Wardensville the 1200 pound application made in 1939 gave highest yields, showing 33 per cent increase over the check plot. Treatment has effected very little change in desirable species on this soil and as a result there has been little response.

Grazing Experiment. The grazing experiment with Ayrshire heifers on Monongahela silt loam at Wardensville, West Virginia, has been completed and is now being prepared for publication. Two papers are being written, one on the correlation of yields of total digestible nutrients as measured by three clipping methods and by grazing, and one on the responses to lime and fertilizer as measured by grazing and clipping.

Title: Pasture Management Studies.

Leaders. F. E. Schaller, G. G. Pohlman and R. M. Smith.

The Kentucky bluegrass-white clover height of cutting experiment at Morgantown showed a relatively small response to both superphosphate and muriate of potash during the 1942 season. This is probably due largely to the fact that there was almost no white clover in these plots either in 1941 or 1942. The plots which were cut twice a year continued to give higher yields than those given frequent clippings. Volunteer white clover began to come into the plots in the latter part of the season. Although the percentage of white clover was still small at the time estimates were made on September 15, there was definitely more white

clover on the closely clipped plots. The plots which received no white clover seed at the beginning of the experiment and consequently never contained large amounts of white clover in any year, were now highest in this legume.

Reseeding Pastures on the Contour. In September 1941, an experiment was started on the Agronomy farm at Morgantown to test the feasibility of reestablishing desirable pasture species on steep hillside pastures by reseeding. A 20 foot strip was laid out on the contour and then divided into 15 twenty-foot square plots. Some of these plots were plowed, some disked, and the others allowed to remain as they were. All plots were then limed, fertilized, and seeded with a mixture of grasses and legumes. In the spring of 1942 this experiment was duplicated on a second contour strip in the same pasture. During the 1942 season yield data were obtained by clipping caged areas. The fall established plots were clipped six times and the spring established plots were clipped three times. In addition botanical estimates were made on all plots.

In general, the results for the 1942 season were as follows:

1. Equally good stands were obtained by fall and spring seeding.
2. Only a very small effect from seed was noted on the plots which were neither plowed nor disked.
3. Yields were about the same on the plots which were disked or plowed but there was a higher percentage of desirable grasses on the plowed area.
4. Manure applied at the approximate rate of two tons per acre was effective in preventing too close grazing of the new seedlings.

TITLES AND NOTES OF MANUSCRIPTS SENT IN BY
COLLABORATORS AND CONCERNED WITH PASTURE
RESEARCH, PUBLISHED OR PREPARED FOR
PUBLICATION DURING 1942

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Kuhn, A. O., and Kemp, W. B. Differences in sugar content of grass associated with soil fertility, growth conditions and growth habit. Jour. Amer. Soc. Agron. 34:672-674. 1942.

McManus, T. B., Bender, C. B., and Garrett, O. F. A comparison of acetic acid, fed in the form of Triacetin with glucose, as a nutrient in feeds. Journal of Dairy Science. 26, No. 1. January 1943.

Odland, T. E., Cox, T. R., and Moran, C. H. Adaptation of various crops for supplementary pasture. Jour. Amer. Soc. Agron. 34:329-237. 1942.

Data collected at the Connecticut (Storrs) Station during the period 1932-41, on the effects of fertilizer treatments on the soil, the flora, and the production as measured by grazing, are being prepared for publication.

A paper will appear in Soil Science Society of American Proceedings 1942 on "Effects of amount and depth of applying limestone as related to the growth of alfalfa in Connecticut".

A bulletin covering grassland investigations during a period of seven years will be published in the near future by the Maine Agricultural Experiment Station.

Grazing Experiment with Ayrshire heifers on Monongahela silt loam at Vardensville, West Virginia has been completed and results now being prepared for publication. One paper will present the correlation of yields of total digestible

nutrients as measured by three clipping methods and by grazing, and the other will describe the responses to lime and fertilizer as measured by grazing and clipping.

A final report on the pasture investigations, carried on at Kylertown, Pennsylvania, by the Pennsylvania Agricultural Experiment Station and the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, will be published early in 1943.

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